

BBC

100

Breakthrough Health Discoveries

THE ULTIMATE GUIDE TO LIVING
A **LONGER, HEALTHIER**
AND **HAPPIER** LIFE



TIME INC. SPECIALS

FROM THE EDITORS OF  **FOCUS**

WELCOME



How do you stay healthy? If you've ever tried to find out, you'll know that there's a lot of conflicting information, from the latest fad diets to ever-changing exercise regimes and a bewildering array of prescription drugs.

The purpose of this special issue is to cut through the hype. Our team of top health writers have looked at the very latest scientific studies and compared them to existing research. The result is a digest of current thinking from the world's leading scientists.

So what's the best way to use it? Well, let's say you eat vegetables because they're good for you. You might be surprised to learn that some are better than others, or that the method of cooking them makes a big difference. Fitness is just as complex. What kinds of exercise should you do, and how long should you spend on them for the best results? You'll find the answers in the Fitness & Nutrition section.

To truly look after yourself, you need a healthy mind as well as a healthy body. So in the Mind & Wellbeing section we've summarised expert advice from psychologists on how to cope with stress, depression and anxiety.

We also bring you the stories behind today's most popular prescription drugs, along with the current medical advances that could help you stay healthy in the future. I'm confident that we've assimilated the very latest information to keep you on the road to a long and happy life. The rest is up to you.

A handwritten signature in black ink that reads "Graham".

Graham Southorn, Editor



100 Breakthrough Health Discoveries

THE ULTIMATE GUIDE TO LIVING A **LONGER,**
HEALTHIER AND **HAPPIER** LIFE

FROM THE EDITORS OF  **FOCUS**

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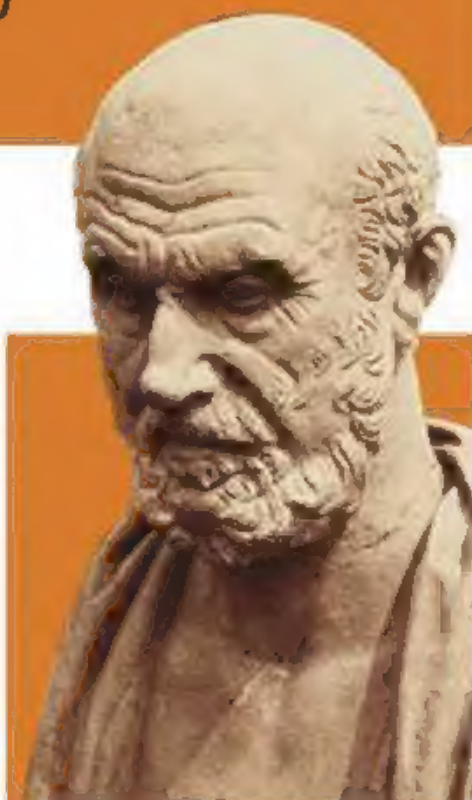


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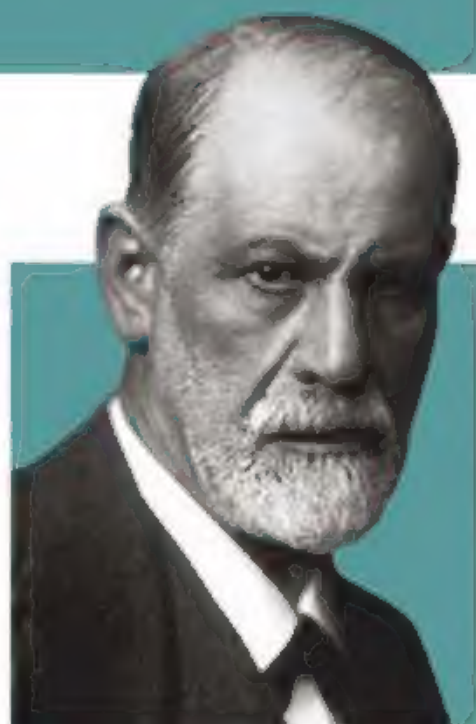
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FITNESS & NUTRITION

HOW WE EXERCISE AND WHAT WE EAT

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-

1 Weekly exercise

You don't have to adopt the training regime of an Olympic athlete to stay in shape

A quarter of UK adults are obese, while more than three million have diabetes. But just 150 minutes of moderate aerobic exercise (any activity that causes a noticeable increase in breathing and heart rate) and two strength sessions each week will ensure you are fit and strong, according to the US Center for Disease Control and Prevention.

You don't need to mimic the routine of US triathlon world champion Gwen Jorgensen and her 30-hour swim, bike and run training

weeks. Instead, aerobic activities can include walking briskly (at around 5km/h), cycling slower than 16km/h and gardening. How you break up those 150 minutes is up to you, but five daily 30-minute activities gives you two days' rest.

Recent research in the journal *Osteoporosis International* has also shown that middle-aged men who strength-trained have a higher bone mineral density than those who don't, highlighting its use as a preventative to osteoporosis.

150 minutes of moderate aerobic exercise each week, plus two strength sessions, will ensure you stay fit and strong

2

Is salt a health hazard?

Study the figures on food packaging in order to keep salt intake – and thus blood pressure – low

If salt consumption is high, the body retains water to dilute the high concentrations of sodium, which in turn increases the volume of blood in the bloodstream and puts more pressure on the heart and blood vessels. This pressure can harden the blood vessels, causing high blood pressure, a condition that – according to a 2009 study by cardiac and vascular scientists at the University of London – accounts for two-thirds of all strokes and half of all heart disease. “A modest reduction in population salt intake worldwide will result in a major improvement in public health,” say the researchers.

The British Heart Foundation recommends that adults should consume no more than 6g (one teaspoon) of salt a day. However, according to NHS estimates, the actual salt intake of the average UK adult is 8.1g a day. To effectively monitor your salt intake, look at the salt/sodium content listed in the nutritional information on food packaging. Anything containing 1.5g of salt (0.6g of sodium) or more per 100g should be approached with caution; anything 0.3g of salt (0.1g of sodium) or less per 100g is fine.

DID YOU KNOW?

Just 15 per cent of the average Briton's daily salt intake occurs naturally in food

3 Taking root

Ginger can relieve muscle pain – and may well ease nausea

Ginger has been found to be an effective muscular pain reliever. When tested on athletes after intense bouts of physical exercise, participants who had received 3.1g of ginger per day experienced significantly reduced muscle soreness, according to a 2013 study published in the *International Journal of Preventive Medicine*.

Other research has focused on testing the conventional wisdom that ginger has a positive effect on nausea. A number of studies published in obstetrics and gynaecology journals worldwide have concluded that ginger can help

relieve sickness during pregnancy when taken in a dose of no more than 1g per day for no more than four days. However, further research is needed to confirm whether ginger is as effective as medication in the management of motion sickness and post-surgical nausea, as well as the reduction of blood pressure and inflammation in treating osteoarthritis.

4 The benefits of oily fish

Omega 3-rich fish, like salmon, eases blood pressure and reduces the build-up of fat – as long as you prepare it in the correct way

Research into the cardiovascular benefits of oily fish such as salmon began when scientists noted the low rates of heart disease in Inuit communities. The American Heart Association recommends consuming at least two portions of oily fish a week, to decrease blood pressure and fat build-up in the arteries – although the British Heart

Foundation, which once offered similar advice, retracted the recommendation in 2013.

A 2014 review by Saint Luke's Mid America Heart Institute in Kansas City found compelling evidence that eating the right type of Omega 3-rich fatty fish twice a week can also prevent the development of cancerous tumours that lead to breast,

colon, intestine and oesophageal cancers. The authors stressed the importance of preparation method: in the Italian studies they reviewed, participants who ate oily fish twice a week were at particularly low risk for a number of cancers. Fish was prepared using olive oil, which is naturally low in Omega 6, and without frying or salt preserving.

Studies in Italy found that eating oily fish cooked using olive oil significantly reduced the threat of cancer



5 How sound and vision can motivate

Train your brain to sidestep those feelings of fatigue

Why do we stop exercising? The nature of exercise-induced fatigue isn't entirely understood, but research by Professor Samuele Marcora of Bangor University in Wales suggests it's not due to your muscles giving in. Instead, it's a decision-making process based on perception of effort and motivation that Marcora calls the "psychobiological model of fatigue".

Thirteen subjects rode on static bikes until exhaustion. As they pedalled, a screen periodically flashed images of happy or sad faces in 16-millisecond bursts – 10-20 times quicker than a blink. "The cyclists who were shown sad faces

rode for 22 minutes and 22 seconds," says Marcora. "Those shown happy faces rode for three minutes longer and reported less of a sense of exertion."

In a second experiment, Marcora demonstrated that subliminal action words (like 'go' and 'lively') boosted a subject's performance by 17 per cent over inaction words ('toil' and 'sleep'). In the future, these messages and images could be combined with mobile display technology such as Google Glass to give athletes an advantage over their rivals.

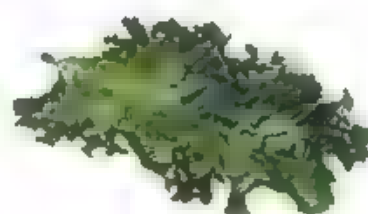


6 The holy kale

This green vegetable's health benefits are undeniable – just make sure you cook it correctly

This member of the cabbage family has recently experienced a boost in popularity thanks to a string of celebrity endorsements about its health benefits. It is very high in vitamins K and C, as well as calcium. Additionally, kale contains high levels of sulforaphane, which has powerful anti-cancer properties. A 2013 study by researchers at Zhejiang University in China, published in the *World Journal of Urology*, has found that an increased intake of cruciferous vegetables is related to a decreased risk of bladder cancer.

However, the cooking method used makes a significant difference to anti-cancer properties.



DID YOU KNOW?

Kale is so packed with nutrients that, per calorie, it contains more calcium than milk and more iron than beef!

According to researchers at the medical and chemistry faculties at the University of Warwick in the UK, boiling brassica vegetables for 10 minutes depletes valuable glucosinates by as much as 40-50 per cent, while steaming, microwaving or stir-frying retains all of these compounds. Different storage methods, on the other hand, were found to have little impact on glucosinate retention.

7

Is a gluten-free diet healthier?

Cutting out so much fibre may weaken your health

Switching to a gluten-free diet is only recommended if, after a blood test and intestinal biopsy, you've been diagnosed with coeliac disease, an inflammation of the intestine caused by gluten consumption. Switching before this test can impair the production of antibodies and delay an accurate diagnosis. Symptoms of coeliac disease, which affects around 1 per cent of the UK population, include diarrhoea, abdominal pain and bloating after eating wheat, rye and barley. Gluten sensitivity is a condition with similar symptoms that might also require a gluten-free approach, but it doesn't damage the

intestine and won't show up in a blood test, so the advice of a gastroenterologist should be sought.

By cutting out gluten, the body is deprived of a good source of fibre, along with vital vitamins and minerals, so it's not a wise choice for weight loss or general health. If you have been advised to consume gluten-free products – bread, for example – they should be fortified with vitamins and minerals to replace those supplied by foods that contain gluten. Quinoa, millet, amaranth and buckwheat are all examples of nutritious, gluten-free grains.



8 The green-skinned monster

Don't be alarmed by the high fat content of an avocado – it's full of those 'good' fats and can also suppress appetite

Dieters are often warned off avocados on account of their high fat content. While it's true that fat makes up 75 per cent of the calories in the fruit, these are naturally 'good' fats, such as monounsaturated fat. Research published in the *Archives of Medical Research* has shown that following a diet enriched with avocados actually lowers 'bad' LDL cholesterol by almost a quarter, while increasing levels of the 'good' HDL cholesterol by 11 per cent.

Contrary to the belief that avocados should be omitted from calorie-controlled diets, a 2013 study by nutrition scientists at Loma Linda University in Los Angeles found that they can play a useful role. Participants who ate half an avocado with their lunch reported a 40 per cent decreased desire to eat three hours later. They

showed no signs of elevated blood sugar, indicating that avocados may have a regulating effect on glucose levels. A study published in *Nutrition Journal* in 2013 concluded that avocado consumption is associated with improved overall diet quality and reduced risk of metabolic syndrome, the symptoms of which include diabetes, stroke and coronary artery disease.



TOP TIP

Fresh beetroot can be bought year round, but they are sweetest and most tender between June and September

9 Beet generation

The nitrate-heavy properties of beetroot mean that drinking its juice boosts both blood flow and stamina

Beetroot's unusually high level of nitrates is credited for the blood flow-boosting properties that have been the subject of so much recent research. A glass of beet juice significantly lowers systolic blood pressure for several hours, according to studies carried out in 2010 at Queen Mary's University in London and in 2012 at the Baker IDI Heart & Diabetes Institute in Melbourne, Australia.

A team at the Wake Forest Translational Science Center in North Carolina also found that drinking beet juice had a positive impact on blood flow to the brain, particularly the frontal lobe, which is

the region most affected in dementia patients.

The nitrate content of beet juice can also be useful for boosting stamina in athletes. So say sport scientists at the University of Exeter, who found that two 70ml shots of beet juice taken two-and-a-half hours before exercising decreased the body's oxygen consumption by as much as 3 per cent.



10 The benefits of a morning workout

Raising testosterone levels early on reaps dividends in the afternoon

Testosterone levels are a predictor of physical performance because this particular hormone builds muscle, burns fat and even boosts libido. Testosterone also shows a circadian decline throughout the day, suggesting that the later you train, the worse you will perform.

Professor Liam Kilduff and his team at Swansea University examined the effect of morning

training on testosterone response. Following morning saliva collection, 18 semi-professional rugby players all completed one of three tests: a control (rested), sprint (5 x 40m) or weights (three sets max of bench press and squat) trial. Six hours later, a further saliva sample was taken before the players completed a performance test (back squat and bench press, 40m sprint, jump test).

The results showed circadian decline in testosterone levels was offset by morning training, with the players achieving faster sprint times and greater bench press weights after the morning weights session. It suggests that, for afternoon games in power sports like rugby or sprinting, you will perform better after a short, early-morning weights session.

Testosterone is a hormone that builds muscle, burns fat and even boosts libido



11 Going nuts

Significantly lower your risk of heart attack by making almonds part of your regular diet

A Harvard study published in the *New England Journal of Medicine* in 2013 found that nut consumption is associated with a decreased risk of mortality. "Compared with participants who did not eat nuts, those who consumed nuts seven or more times per week had a 20 per cent lower death rate," says the study. Inverse associations were observed for most major causes of death, including heart disease, cancer and respiratory diseases. This conclusion confirms recent findings in the same publication about the heart-protective effects of a Mediterranean diet, which includes

an average of 28g of nuts per day. A research team at Aston University in the UK has confirmed that eating a handful (50g) of almonds every day for a month resulted in increased

levels of antioxidants in the bloodstream, improved blood flow and lower blood pressure, potentially reducing the risk of a heart attack.



12

What's the healthiest oil to cook with?

Why selecting the best is a numbers game

In recent years, concerns about saturated fat intake have prompted consumers to reject traditional cooking fat in favour of vegetable-based oils, which are rich in monounsaturated and polyunsaturated fats. But these fatty acids, also known as Omega 3, 6 (both essential) and 9 (non-essential), are only beneficial if Omega 6 content doesn't vastly outweigh Omega 3 content. While Omega 3 fatty acids reduce the risk of heart disease, over-consumption of Omega 6 has been identified as a risk factor in cardiovascular disease and death,

according to 2005 research published in the *Annals of the New York Academy of Sciences* and a 2009 study in *Biochemical Pharmacology*.

In many western diets, Omega 6 intake outweighs Omega 3 by up to 50:1, rather than a healthy maximum of 5:1. So, the healthiest cooking oils have the least Omega 6. Olive oil – only 9 per cent Omega 6 to sunflower oil's 71 per cent – is the healthiest oil for cooking, and promotes the generation of disease-fighting antibodies, according to trials conducted by the EUROLIVE study group in 2010.



13 **Does kelp help?**

The Japanese eat this seaweed in vast quantities – and they have the longest life expectancy on the planet

Nutrition experts have become interested in the properties of this common seaweed since observing its impact in the much-studied diet of the Japanese, who have an average life expectancy of 83 years – the highest in the world. According to a 2014 study by scientists at Newcastle University, a compound found in kelp called alginate prevents the body

from absorbing fat. The research, published in the journal *Food Chemistry*, showed that alginate suppresses the digestion of fat in the gut. Even in small quantities, the fat intake of participants who consumed bread with added alginate was reduced by a third;

the compound blocks the activity of a digestive enzyme, pancreatic lipase, which breaks down fat for absorption.

However, kelp also has a particularly high iodine content. This can be beneficial for those suffering iodine deficiency (though this condition is rare), but high doses consumed as a supplement can overload the body and cause hyperthyroidism.



14

Running on empty

For endurance athletes looking to burn fat, exercising when glycogen levels are low can be beneficial

Carbohydrate-based energy drinks like Gatorade and Powerade are omnipresent at gyms across the nation. But the idea that they should fuel every session is incorrect, according to research led by John Hawley, Professor of Exercise Metabolism at RMIT University in Melbourne, Australia.

Hawley and colleagues have shown that undertaking regular training sessions in a glycogen-depleted state drives up the metabolic adaptations to burn fat. "The idea is that this enhances stamina and endurance, because glycogen depletion is associated with fatigue," says Hawley.

For endurance athletes like marathon runners and triathletes, this is the Holy Grail. Your body stores around 1,800 carbohydrate calories in a form called glycogen in the liver and muscle cells, before releasing it into the bloodstream in the form of glucose. It's then broken down in cellular powerhouses called

mitochondria, one of the results of this being energy.

But running a marathon can burn around 1,000 calories an hour, leaving a shortfall if you rely on carbs. That's where fat comes in. Even a fit marathon runner stores up to 100,000 calories of fat in muscle fibres and fat cells. So, by training with low glycogen levels, your body has no choice but to use fat stores.

"The main adaptation to fasted endurance sessions is enhanced mitochondrial volume in the muscles, which means all the enzymes and sites involved in aerobic metabolism are unregulated to a greater extent," says Dr James Morton of Liverpool University. "As a result of those changes, it tends to mean you use more fat as fuel for a given intensity."

And that last point is key. How hard you train is affected by muscle and liver glycogen levels. If they're low, blood glucose levels will be low too, making the session feel harder. That's why it's appropriate to

undertake fasted efforts during the winter and spring, when you're looking to increase aerobic capacity and fat-burning capabilities by training at a moderate intensity. "When you increase the intensity of your sessions as your race approaches, make sure you go back to the carbohydrates," warns Morton.

Hawley and his team have also shown that you can increase the intensity of fasted sessions by drinking a cappuccino. "When athletes train with low glycogen, their power output drops by 8 per cent," he says. "With a shot of caffeine, it rescues it to around a 3.5 per cent drop while enjoying the benefits of burning more fat."

One session a week in a fasted state will improve endurance athletes' aerobic capacity and their ability to burn fat. This should be longer than an hour, at an intensity no greater than around 75-80 per cent of your maximum heart rate, and done before breakfast.



Undertaking regular training sessions in a glycogen-depleted state drives up the metabolic adaptations to burn fat

15

Keep active

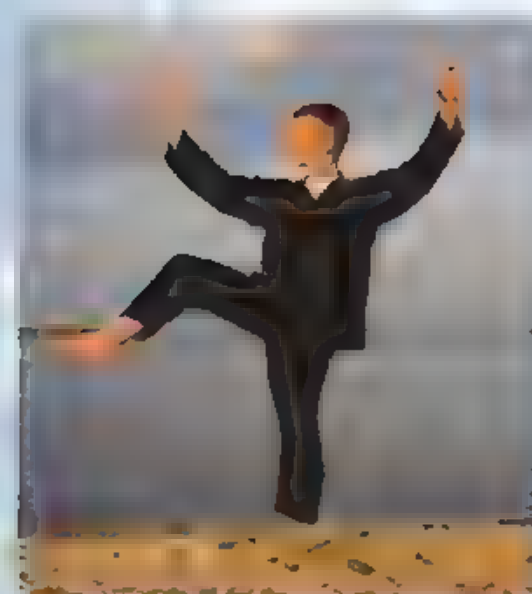
The gym-phobic need not worry. Here are five key activities that can help weight, bones and general fitness

If the thought of sweaty gymnasiums fills you with dread, fear not. According to the Harvard Medical School, there are five key activities that will keep your weight under control, strengthen your bones and improve general health as you age.

Number one is **swimming**. Water is about 800 times denser than air, providing around 12 times more resistance. That's why each stroke not only increases shoulder, chest, arm and leg strength, but also works the lungs and heart. According to Dr I-Min Lee, Professor of Medicine at Harvard, it's also "good for individuals with arthritis because it is less weight-bearing".

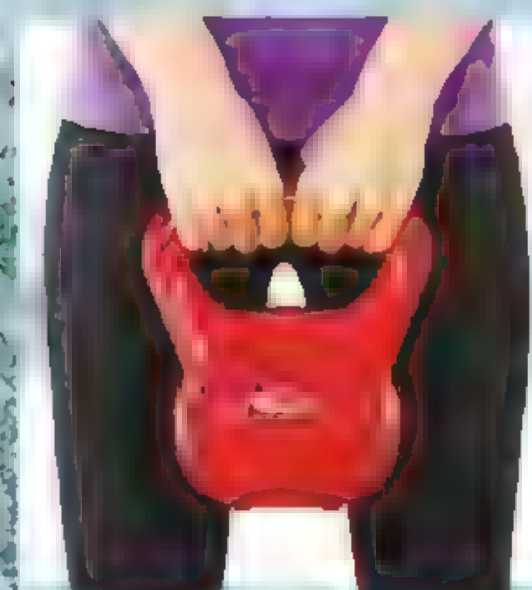
Tai chi takes the number two slot. The Chinese martial art trains both mind and body. "It is also particularly good for older people," explains Dr Lee, "because balance is an important component of fitness and that is something we lose as we age."

The remaining three all-over exercises are: **strength training**, which maintains muscle mass that naturally decreases as you age; **walking**, which has been linked with improved memory; and **Kegel exercises**, which consist of repeatedly contracting and relaxing the pelvic muscles, and help to reduce urinary incontinence.



TAI CHI

Its emphasis on balance means it appeals greatly to older people



STRENGTH TRAINING

Helps to maintain muscle mass that declines with age



WALKING

Linked to improved memory



KEGEL EXERCISES

Helps to reduce urinary incontinence

16 The mighty quinoa

Unlike wheat, rice or oats, nutrient-heavy quinoa contains all 10 essential amino acids



This ancient pseudo-grain, prized by Inca warriors for its fortifying properties, counts protein, magnesium, calcium and iron in its nutritional content, and has been singled out by the Food And Agricultural Organization of the United Nations for its "high nutritive value". A 2009 review published in the *Czech Journal of Food Sciences* confirmed quinoa's superior

nutritional make-up. One of the reasons for its recent resurgence is that, unlike wheat, rice or oats, it contains all 10 essential amino acids and, unusually, a protein content of 14-18 per cent. Consumers are discovering what NASA has known for two decades: "While no single food can supply all the essential life-sustaining nutrients, quinoa comes as close as any other in the

plant or animal kingdom," said a 1993 technical paper by the organisation.

Recent research, by the University of Paraná in Brazil, has focused on its anti-inflammatory impact on the digestive system. Elsewhere, a study at King's College London (published in the *American Journal of Gastroenterology* in 2014) considered its use as a gluten-free carbohydrate easily digestible by coeliac sufferers.



17 **Bean benefits?**

Coffee's potential health gains may depend on genetics

Well-publicised epidemiological studies (those that look at associations rather than direct cause and effect) have shown that coffee consumption can decrease the risk of some diseases such as Alzheimer's, dementia, heart disease, Parkinson's and type 2 diabetes, and increase the risk of others, such as anaemia.

Further studies by the New York State Department of Health in 2011 have suggested that the impact of coffee on Parkinson's disease risk is dependent on the genes of the individual. Another piece of research, conducted by the University of Toronto, suggests that if a specific gene, CYP1A2, expresses itself one way, caffeine is metabolised slowly, increasing risk of heart disease, while if it expresses itself another way, coffee is metabolised quickly, leading to a decrease in this risk.

So although we know with certainty that coffee is high in antioxidants – this was confirmed in antioxidant ratings compiled by the University of Oslo in 2010 – and has potential health benefits, more research (and individual genetic testing) is required before these findings can be used to recommend coffee consumption.



18 Is red meat bad for your health?

An advisable way to lessen the risk of cancer and heart disease is to reduce the consumption of red meat

In 2005, the US Dietary Guidelines for Americans recommended that consumption of red and processed meat should be moderated. Results of subsequent research have been mixed. A 2009 Harvard review of 20 studies found a link between the consumption of processed meats and a higher incidence of coronary heart disease and diabetes mellitus, but no link with red meat.

More recently, research led by Harvard Medical School and Harvard School of Public Health concluded that red meat consumption was "associated with an increased risk of cardiovascular disease and cancer in men and women".

What both of these heavyweight studies agree on, however, is that processed meats have a negative impact on health. The American Institute for Cancer Research advises no more than 510g of cooked red meat a week and complete abstinence from all processed meats such as sausage, deli meats, ham, bacon and hot dogs, citing research that shows an increased risk of colon cancer. In limited quantities, unprocessed, grass-fed beef is best, say recent studies in California and Melbourne, Australia. It is leaner and contains higher levels of more healthy Omega 3's than grain-fed beef.

The American Institute for Cancer Research advises no more than 510g of cooked red meat a week – and complete abstinence from processed meats such as sausage, deli meats, ham, bacon and hot dogs

DID YOU KNOW?

Scientists and lab technicians drink more coffee than any other professional group





19 Sweet dreams

The evidence is clear – there's a direct link between sugar consumption and weight gain

In 2013, a comprehensive review of the extensive research on the relationship between sugar and obesity was commissioned by the World Health Organization (WHO). The results were compelling: a reduced sugar intake was associated with an average 0.8kg (1.76lb) loss in weight, while an increased intake was associated with a corresponding 0.75kg (1.65lb) gain. The review strengthened the link between intake of dietary sugars and obesity, and therefore a higher risk of chronic diseases.

As a result, the WHO reduced its recommendation on sugar intake from a daily limit of 10 per cent of calorie intake to 5 per cent – that's around six teaspoons a day for the

average adult. As part of a healthy diet, this amount of added sugar is not a health threat, but as the average can of carbonated soft drinks – identified by many studies as the worst source of 'empty calories' – contains nine teaspoons, the limit is low. Unfortunately, research has suggested that alternatives like artificial sweeteners actually make us eat more. They don't deliver a second dopamine 'hit' from glucose absorption in the stomach, keeping us hungry.

People with diabetes are advised to monitor their carbohydrate intake, which includes sugar, and eat no more than 65 per cent carbohydrates in their diet.

DID YOU KNOW?

Around 15 per cent of UK children's total energy intake is from sugar



The World Health Organization now recommends sugar intake shouldn't exceed 5 per cent of calorie intake, the equivalent of six teaspoons a day

20 Love that skin

Both delicious and nutritious, the sweet potato is rich in vitamins A and C, fibre and potassium

The Washington DC-based Center for Science in the Public Interest has listed sweet potato as one of the highest ranking foods for nutritional value, due to high levels of dietary fibre, vitamin C and vitamin A. A medium-sized baked sweet potato contains 561 per cent of the average daily requirement for vitamin A, which can prevent the onset of macular degeneration and decrease the risk of cancer. The Nurses' Health Study at Harvard Medical School found that women with diets rich in sources of beta-carotene, like sweet potatoes, reduced

their risk of breast cancer by 25 per cent.

Eat the skin as well as the flesh to increase your intake of fibre, quercetin and potassium, a mineral that is abundant in sweet potatoes and lacking in the diets of most US adults. According to the National Health and Nutrition Examination Survey, fewer than 2 per cent meet the daily 4,700mg requirement for potassium, which lowers blood pressure while, says research published in *Today's Dietitian*, also decreasing risk of dying from all causes by 20 per cent.



21

Drink up!

Boost your antioxidant count with a daily glass of delicious pomegranate juice

Consuming a 250ml glass of antioxidant-rich pomegranate juice a day can slow the progress of prostate cancer, according to a 2006 study at the University of California. It can also, says the Preventive Medicine Research Institute, also in California, lower the risk of heart disease by improving blood flow to the heart. A 160ml glass of 100 per cent juice counts as one of the five portions of fruit and vegetables recommended per day.

However, even a daily shot of as little as 50ml, if consumed over a

longer period of three years, has been found to reduce cholesterol build-up and halve the damage caused by cholesterol in the arteries.

More recent research by food scientists at the University of Huddersfield has been investigating pomegranate's ability to slow the onset of Alzheimer's and Parkinson's disease. The chemical compound punicalagin is thought to inhibit the inflammation in the brain that causes these neurodegenerative diseases.

DID YOU KNOW?

The pomegranate was first introduced to California by Spanish settlers in 1769

22

Walk to a better life

When it comes to looking after your heart, walking is actually better for you than running

"An early morning walk is a blessing for the whole day," said philosopher Henry Thoreau – and he was right. A recent study led by Sophie Lalande, of the Mayo Medical School in Minnesota, examined the effects of a three-month interval-walking programme on the peak aerobic capacity (the maximum amount of work you can do as measured by oxygen consumption) and cardiovascular risk factors of middle-aged sedentary individuals.

The study's participants were divided into two: 17 in the non-training group, 29 in the walking group. The walkers undertook five or more sets of three-minute low-intensity walking interspersed with three minutes of high-intensity walking for an average of four days a week. Three months of interval walking increased peak aerobic capacity by an average of 28 per cent and also reduced systolic blood pressure – a factor in hypertension.

In fact, walking is better for you than running. Scientists at the Lawrence Berkeley National Laboratory in California observed participants aged between 18 and 80 over a six-year period and found that walking reduced the risk of heart disease by 9.3 per cent, while running reduced it by 4.5 per cent.



23

Should we snack?

Isn't eating three square meals a day enough?

Research published in the *Journal of Nutrition* in 2011 suggests that adding three snacks to a regular schedule of three meals may offer small benefits, particularly if snacks contain protein: crackers with houmous, for example, or a piece of fruit with a yogurt. At a 2009 American Society for Nutrition symposium on eating frequency and snacking, experts from Purdue University in Indiana

concluded that "an eating frequency in the range of 3-6 times per day is preferred, provided that... daily energy intake does not exceed energy requirements".

A review carried out by the European Food Information Council in 2007 found that "eating more frequently may promote satiety, favours eating earlier in the day, and may increase carbohydrate intake while decreasing fat consumption", as well as being "associated with a lower risk of heart disease due to a lower level of both total and LDL cholesterol". However, the same caveat was applied here: for snacking to be beneficial, total daily calorie intake must not increase.



ISTOCK

TOP TIP

Eating plenty of protein at breakfast time has been shown to reduce snacking cravings later in the day



24 The seven-minute workout

This short exercise regime will fit into your busy lifestyle

In this time-starved world, exercise is often the first casualty. Enter the seven-minute total workout that strengthens muscles and the cardiovascular system. Authors

Chris Jordan and Brett Klika from the Human Performance Institute in Orlando, Florida studied a plethora of sports science research to create a 12-exercise workout,

the equipment needed for which is nothing more than a chair and a wall. "The exercise strategy is high-intensity circuit training using bodyweight," says Jordan. "Our approach combines aerobic and resistance training into a single exercise bout lasting seven minutes."

The minimal equipment requirement is great for those who can't always get to a gym, with the order of exercises moving between the upper body, lower and core to maintain a high heart rate while maximising strength benefits. Exercises are performed for 30 seconds, with 10 seconds of transition time between bouts; the circuit can be repeated two or three times.

The varied workout consists of jumping jacks, wall-sits, push-ups, abdominal crunches, step-ups onto the chair, squats, tricep dips, planks, running on the spot, lunges and side planks.

25 Mixing it up

Why a varied fitness regime is vital

"A good coach will ensure the training plan is varied enough to keep you interested, while still hitting your physical targets. It certainly helps my sprinting performance." These are the words of cyclist Marcel Kittel, the winner of four stages of the 2014 Tour de France.

Kittel's anecdotal feedback is supported by science. Research from the University of Florida divided 114 subjects into three groups: one where the type of exercise varied between workouts, another whose sessions didn't change, and a third with no set schedule. The participants in the first two groups were told to exercise three times a week and given set guidelines; the third group could exercise how they wished. All three groups did this for eight weeks. The results showed that the first group were 15 per cent more



TOP TIP

If running is part of your cardio regime, stay fresh by using different routes and terrain, and by varying the intensity

likely to stick to their training routine than group two and 63 per cent more likely than the third group.

"It seems variety increases adherence to an exercise routine," says Christopher Janelle, one of the Florida researchers. "Variety also increased enjoyment, which again increased adherence."



THE PIONEER

Hippocrates

Born: circa 460 BC, Cos, Greece
Died: circa 370 BC, Thessaly, Greece
Known for:

Being the 'father of Western medicine'

VIRTUALLY NOTHING IS known for certain about Hippocrates, even which (if any) of the treatises attributed to him he might have written. However, his 'works' – written by various hands over around 200 years and collected centuries later – along with the writings of the later physician Galen (circa 129-216 AD) dominated medical thinking and practice until the 17th Century.

These works cover the whole of medicine and surgery, including disease prevention and treatment. Hippocrates viewed disease as a natural phenomenon, so secular doctors – rather than priests or shamans – were the appropriate port of call. Disease was the result of imbalance of the four humours (blood, bile, black bile, phlegm) whose perfect balance yielded health. Moderation was key to Hippocratic notions of a healthy lifestyle; 'his' treatises provide dietary advice and value exercise.

Because the humours were diffused throughout the body, the Hippocratic writers viewed their patients holistically. They paid attention to living conditions, food, clothing and occupation as important in shaping a person's balance and guiding the doctor. Homeopathy, chiropractic, osteopathy, herbalism and many other modern healing systems look to Hippocrates as a founding father.



John Yudkin

Born: 8 August, 1910, London, England
Died: 12 July, 1995, London, England
Known for:

Highlighting the dangers of excessive sugar consumption

LONDONER JOHN YUDKIN investigated the metabolic effects of vitamins; his concerns with nutrition and health were furthered by studies during World War II on social deprivation and haemoglobin levels, weight and strength.

In 1954, he became the founding professor of the Department of Nutrition at Queen Elizabeth College, London, which attracted students from all over the world. After post-war food rationing in the UK ended, some aspects of health improved, but rates of obesity and cardiovascular disease also increased. Yudkin's investigations pointed to the huge increase in sugar consumption as a major culprit. Yudkin made his case that sugar was implicated in many of the diseases of modernity: it was "pure, white, and deadly", as the title of his 1972 book had it.

Yudkin's work attracted interest and criticism in equal measure, not only from confectionery manufacturers but other nutritionists who favoured alternative dietary and lifestyle explanations for modern health problems. There has recently been a resurgence of interest in his research, as rates of obesity, diabetes and liver disease continue to be high.

Nutritionist
 Yudkin famously described sugar as "pure, white, and deadly"

ERS

THESE FOUR CRUCIAL FIGURES
EMPHASISED THE EFFECT OF
LIFESTYLE CHOICES ON HEALTH



William (Bill) Jay Bowerman

Born: 19 February, 1911, Portland, Oregon

Died: 24 December, 1999, Fossil, Oregon

Known for:

**Popularising the pursuit
of jogging**

EXCEPT FOR HIS time with the US Army in Europe during World War II, Bowerman spent most of his life as a track coach in Oregon. He was phenomenally successful in developing top-class athletes, producing 31 Olympians. His methods were systematic and thorough rather than unorthodox, but he helped the USA Olympic Team during the 1968 Mexico City Games by insisting on high-altitude training.

Bowerman became a household name in the 1960s when, after visiting fellow athletics coach Arthur Lydiard in New Zealand, he introduced jogging to the United States. Bowerman, along with a cardiologist, produced a short booklet in 1962; a longer version in 1966 sold a million copies. Bowerman and others were instrumental in creating clubs and structures that allowed athletes to continue to run throughout their lives. Many studies since have demonstrated the health benefits of jogging, a pursuit that can be done almost anywhere and that requires minimal equipment, other than running shoes.

To that end, in 1964 Bowerman co-founded, with partner Phil Knight, a small footwear company called Blue Ribbon Sports. Seven years later, it was renamed Nike.

Bowerman's
90-page book
on the benefits
of jogging was
a million-seller

Ernst Ludwig Wynder

Born: 30 April, 1922, Herford, Germany

Died: 14 July, 1999, New York City, USA

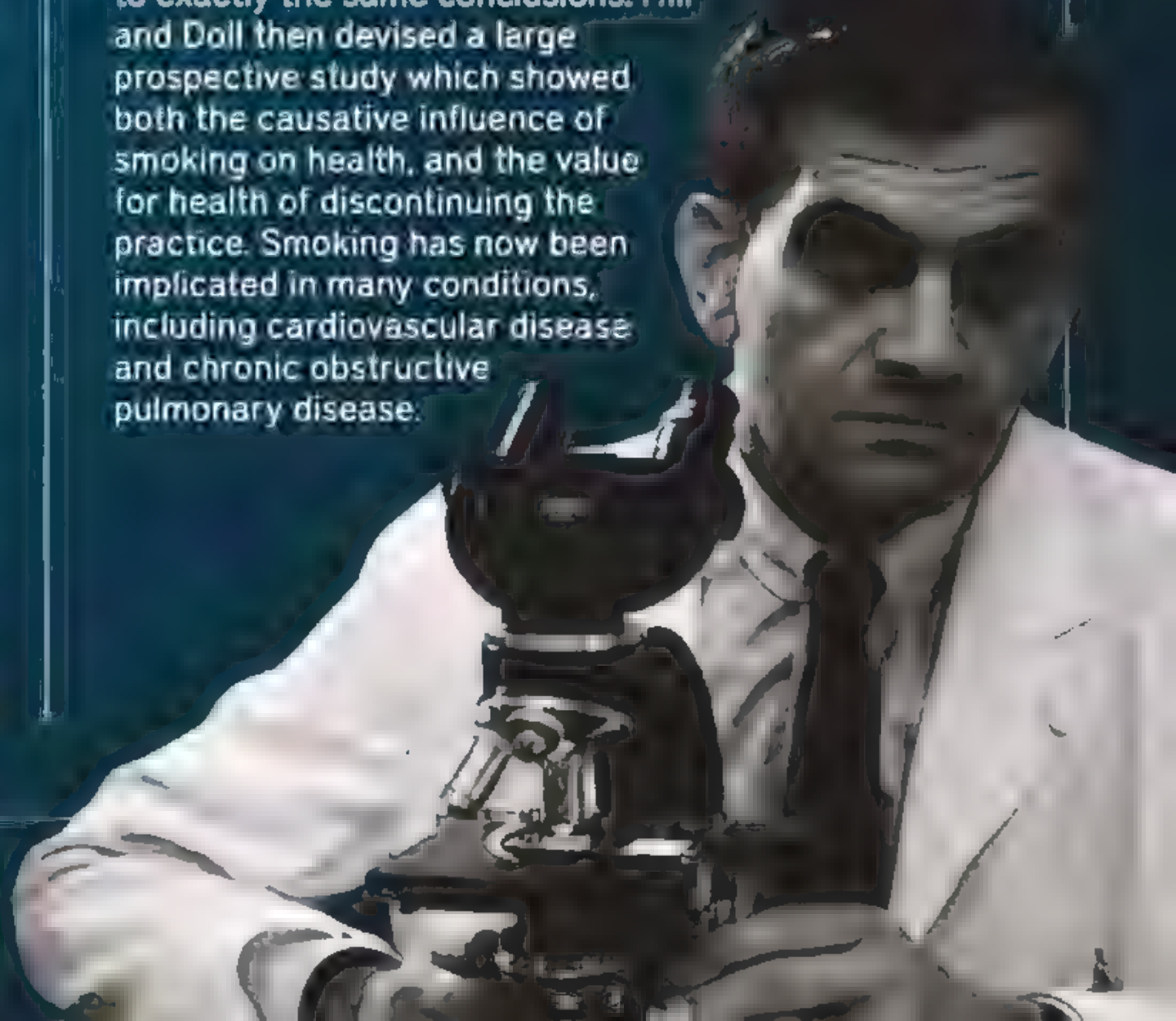
Known for:

**Establishing a link between
smoking and cancer**

THE LEAVES OF the tobacco plant were used in the Americas long before Europeans arrived. Smoking was taken up in Europe soon after the dried and cured leaves were brought there, and the habit has always had its detractors – and enthusiasts. Cigarettes became very common after World War I, and by the 1940s doctors had noticed that lung cancer, a rare disease in the 19th Century, was on the increase.

In 1950, two groups – one in the USA, the other in the UK – nailed down the causal relationship between these two phenomena. In the US, Ernst Wynder, a medical student and junior doctor, collaborated with Evarts Graham, a much older surgeon, in linking smoking habits to patients being operated on for lung cancer. Wynder's findings were extremely significant.

In the UK in the same year, medical statistician Austin Bradford Hill and clinician/epidemiologist Richard Doll conducted hospital-based life histories that came to exactly the same conclusions. Hill and Doll then devised a large prospective study which showed both the causative influence of smoking on health, and the value for health of discontinuing the practice. Smoking has now been implicated in many conditions, including cardiovascular disease and chronic obstructive pulmonary disease.



DRUGS & VACCINES

THE MEDICATION THAT TRANSFORMED OUR LIVES

➕ How was **PENICILLIN** discovered?

➕ Which drug eases the lives of **ASTHMA SUFFERERS**?

➕ How is **HIV** being kept under control?

➕ Which drug has **SAVED THE SIGHT** of millions?

➕ Does **WARFARIN** actually thin the blood?

➕ How does insulin bring relief to **DIABETICS**? ...



26

Happy accident

How unforeseen circumstances led to the discovery of bacteria-busting penicillin

JUST HOW ONE of Alexander Fleming's petri dishes of bacteria became accidentally contaminated with fungal spores in 1928 remains unknown, but its huge effect on modern medicine is beyond debate. When the Scottish microbiologist found the dish a few days later, he noticed all the bacteria surrounding the fungus were dead; the fungus must be secreting something deadly to bacteria. Inadvertently, Fleming had discovered penicillin.

The penicillins are a family of antibiotics which kill bacteria by

interfering with the production of their cell walls. Before their discovery, people could die from infected cuts, but once mass production began in the 1940s, many previously fatal infectious diseases could be controlled. Penicillins are still effective against a range of bacteria, including some staphylococci and streptococci infections. As the first antibiotics, they inspired the search for many more, ushering in the antibiotic age to which we've become so accustomed.



27 Chopping cholesterol

Taken regularly by Britons in their millions, statins can reduce cholesterol and the risk of cardiovascular problems

STATINS ARE A group of drugs that are used widely to reduce the risk of cardiovascular disease in people with high cholesterol levels; they are also taken by those who are already showing signs of the disease. They work by lowering the levels of 'bad' cholesterol – or low-density lipoprotein – in the

blood by decreasing its production by the liver.

An estimated 6-7 million people use statins in the UK. Studies have found that they can reduce the risk of 'adverse events', such as heart attacks or strokes, but they can also have side effects, such as muscle pain and an increased risk of

diabetes. This means it's important to determine if any benefit gained from them outweighs the risks. There is therefore disagreement over what someone's risk of heart disease must be before they are prescribed statins. Some even doubt whether lowering cholesterol has a positive effect on the condition.



Statins lower the levels of 'bad' cholesterol in the blood by decreasing its production by the liver

28 The multi-tasking medicine

It kills pain, but aspirin has preventative qualities too

FOR SOMETHING THAT'S a staple of domestic medicine cabinets, aspirin has a long history. It's thought that people have been using salicylic acid, the active ingredient in aspirin, to treat pain and fever for around 4,000 years, most often in the form of willow and myrtle.

In 1899, the German drug company Bayer released the modern version of aspirin and it quickly became a bestseller. But it wasn't until the 1970s that the British researcher Sir John Vane discovered how it works. Aspirin blocks the production of a group of chemicals in the body called prostaglandins, which play a role in inflammation and transmitting pain messages.

Aspirin also thins the blood, so as well as being used for mild pain, many people take aspirin daily to prevent heart attacks, strokes and blood clots. Not everyone should do this, however, as aspirin can cause bleeding from the stomach. Recent research suggests that daily aspirin might also help to prevent several types of cancer, including bowel and stomach.

People have been taking salicylic acid, the active ingredient in aspirin, for more than 4,000 years



29 **Breathe easy**

The speedy development of salbutamol brought quick relief to asthma sufferers

SELF-EXPERIMENTATION HAS a long history in medical research and it was in part because of its inventors' willingness to be test subjects that salbutamol, the most commonly used asthma drug, was available just three years after it was discovered.

Asthma is a chronic condition affecting more than 235 million people worldwide. During an asthma attack, the inflamed lining of the airways swells and the muscle contracts, reducing airflow into the lungs. In the early 1900s, scientists discovered that adrenalin opened people's airways, but the effects were

short-lived and the adrenalin caused their hearts to race.

In the late 1960s, UK researchers created a drug that mimicked adrenalin's effects on the airways, and salbutamol was introduced in 1969. The team's head, David Jack, was the first to take it, and tests on him determined its side effects and correct dose. The Food and Drug Administration approved the drug in 1982.



30 **Insulin injections**

The lives of millions of diabetics were greatly improved by the discovery of this life-saving hormone

PICTURE THE SCENE. It's 1922 and 50 children lie on a Toronto hospital ward in diabetic comas, close to death. Doctors move from one to the next, injecting them. As the last children receive injections, the first are waking. This may be an embellished – perhaps even fictional – account of one of the first uses of insulin, but it does help us understand the enormous effect it has subsequently had on diabetes.

Insulin is a hormone made by specialised cells in the pancreas. Without it, glucose isn't transported into cells, causing high levels of blood glucose and various fatal

consequences. The only option was a starvation diet.

In 1921, Canadian scientists Frederick Banting and Charles Best found that injecting mashed-up pancreas extracts into pancreasless dogs kept them alive. They then isolated insulin from the pancreases of cattle and pigs – the main sources of insulin for decades. In the late 1970s, US researchers produced the first modern insulin by genetically engineering *E. coli* bacteria to produce human insulin.

DID YOU KNOW?

The list of famous personalities who suffered from diabetes includes Elvis Presley, Ernest Hemingway, Ella Fitzgerald, Johnny Cash and tennis champion Arthur Ashe





31 Preventative measures

Mass vaccination meant protection from infectious diseases

ASK PEOPLE WHO invented vaccination and many will say the 18th-Century British physician Edward Jenner. But "the truth is somewhat more blurred and complicated," says Tilli Tansey OBE, Professor of the History of Modern Medical Sciences at Queen Mary University of London.

In fact, a primitive form of vaccination called variolation had been invented in China about 800 years earlier. Variolation involved exposing healthy people to smallpox with inhalable powdered smallpox scabs, or by scratching scab material into the skin.

Variolation spread to the UK, but was not widely accepted. Then Jenner noticed that milkmaids who'd previously had cowpox were protected against smallpox, and found that matter from cowpox skin lesions could also be used to inoculate people against smallpox. The two viruses were similar enough that the immune system 'remembered' the cowpox and so destroyed the smallpox.

"But Jenner's priority is not undisputed," says Tansey. Some 20 years before Jenner, a Dorset farmer named Benjamin Jesty

transferred cowpox material into the veins of his sons, seemingly protecting them from smallpox. "But he was a country farmer, not a well-connected doctor, and he did not publish his results until after Jenner's claims," explains Tansey. By 1980, smallpox, so integral to the invention of vaccines, was the first disease to be fully eradicated.

Vaccines soon improved from crudely prepared extracts of cowpox pustules, as Tansey reveals. "Towards the end of the 19th Century, early pharmaceutical companies started getting involved, thus bringing standardisation, and improving efficacy. They advertised, distributing and selling vaccines more widely, and

A significant breakthrough was the development of freeze-dried vaccines. Without the need for refrigeration, they're easier to send to remote areas

initiated research into producing vaccines against other infectious diseases."

There are now many different types of vaccines, saving millions of lives a year. Some use a weakened, dead or inactivated version of the disease agent to induce an immune response; others are just part of the pathogen or one of its products. Most are given as injections, but some are taken orally, such as polio's liquid vaccine, or in a nasal spray, as in some forms of flu vaccine. A big breakthrough, says Tansey, was the development of freeze-dried vaccines, which reduced the volume to be sent to remote areas and didn't require

refrigeration. New ways of delivering vaccines are under development, such as skin patches covered with tiny needles.

Furthermore, the idea that vaccines can only *prevent* disease is also changing. Therapeutic vaccines are designed to be given after the fact, harnessing the power of the immune response to fight an already-present disease, such as cancer or HIV. Only one such vaccine – a therapeutic vaccine for prostate

cancer called Sipuleucel-T – is currently available, but, though progress has been slower than many had hoped, vaccines could one day be treatment as well as prevention.



32 **Viagra**

The accidental discovery that helped sufferers of erectile dysfunction

VIAGRA, OR SILDENAFIL, is one of the most famous accidental discoveries in science. Researchers working for the pharmaceutical company Pfizer in the UK were testing sildenafil as a blood pressure and angina drug when early safety trials demonstrated that, while it did little for angina, it did induce erections in men. Pfizer switched to marketing it as a drug for erectile dysfunction, naming it Viagra, and FDA approval was granted in 1998. It achieved a staggering \$1 billion in sales in its very first year.

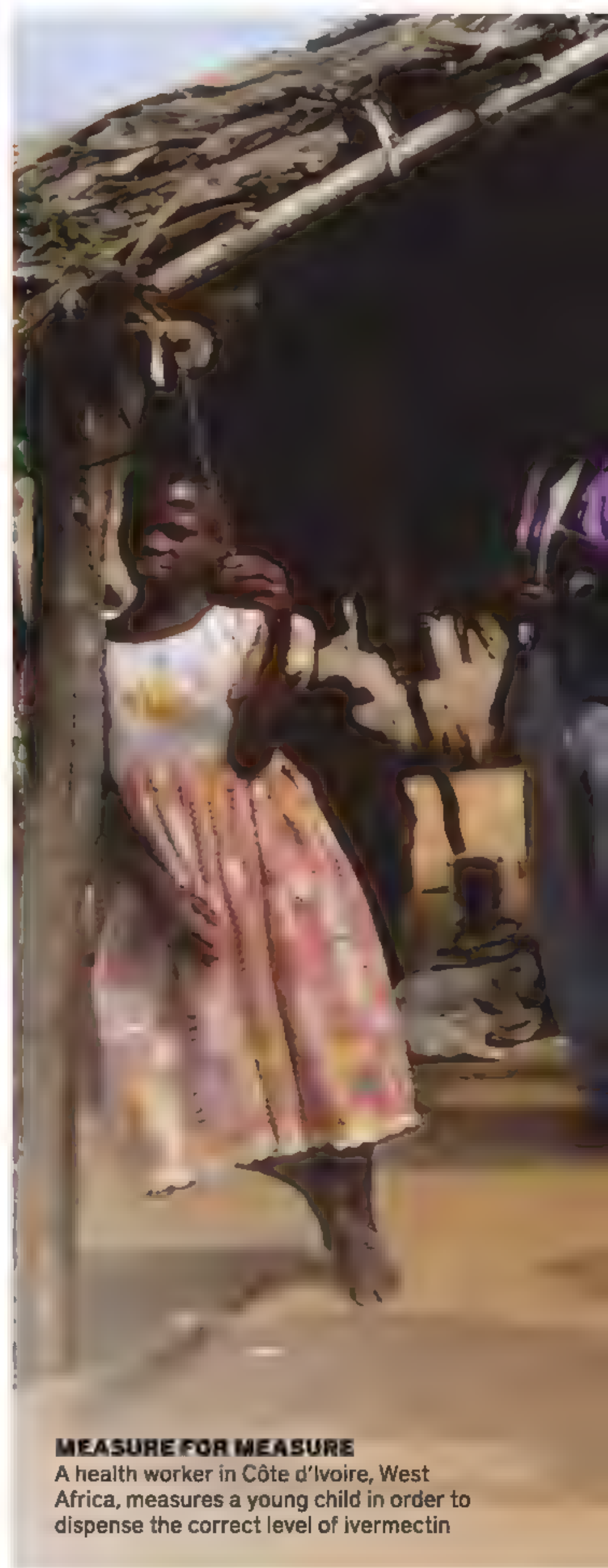
DID YOU KNOW?

The combined global sales figures of the three main drugs that tackle erectile dysfunction – Viagra, Cialis and Levitra – total more than \$4bn per year

Viagra works by relaxing the blood vessels, which allows more blood to flow. This means it can be used to treat pulmonary hypertension, a type of high blood pressure in the blood vessels of the lungs that can lead to symptoms such as shortness of breath and dizziness. It can also be used to treat mountain sickness at high altitudes, where the lack of oxygen constricts the blood vessels in the lungs.

33 **Saving sight**

Ivermectin, the cure for the parasitic disease river blindness, has revolutionised life in Africa



MEASURE FOR MEASURE

A health worker in Côte d'Ivoire, West Africa, measures a young child in order to dispense the correct level of ivermectin

NOT WIDELY KNOWN in the first world, ivermectin is the drug of choice for treating the parasitic disease river blindness, or onchocerciasis. It is caused by the parasitic worm *Onchocerca volvulus*, which infects people via the bite of a black fly that lives near fast-flowing water. The adult worms live under the skin, but their offspring migrate to the eyes, where

the inflammation they cause can lead to blindness. An annual dose of ivermectin for 15 years, the worm's lifespan, stops the disease in its tracks. First introduced in 1981, the drug company Merck has provided ivermectin free of charge to any country that needs it since 1987.

Some 17 to 25 million people in the developing world are infected,

mainly in sub-Saharan Africa. But ivermectin, as part of control programmes across Africa, has played a role in controlling river blindness and allowing people to return to agricultural land that the disease had driven them from in the 1970s. More than 60 million acres of fertile agricultural land are now safe for resettlement.



Since 1987, the drug company Merck has provided ivermectin free of charge to any country that needs it

34 Halting the hurt

Harvested from the opium poppy, morphine works on the central nervous system to tackle severe pain

ANOTHER DRUG WITH a long history, morphine is a strong painkiller and euphoriant found in the opium poppy, *Papaver somniferum*. Opium, a resin extracted from the poppy, contains about 12 per cent morphine, as well as much smaller amounts of painkillers such as codeine. Once the morphine is extracted, it can be further processed into illicit heroin.

Morphine works directly on the central nervous system, binding to opioid receptors on nerve cells in the brain, spinal cord and gut, and silencing pain signals. The painkilling

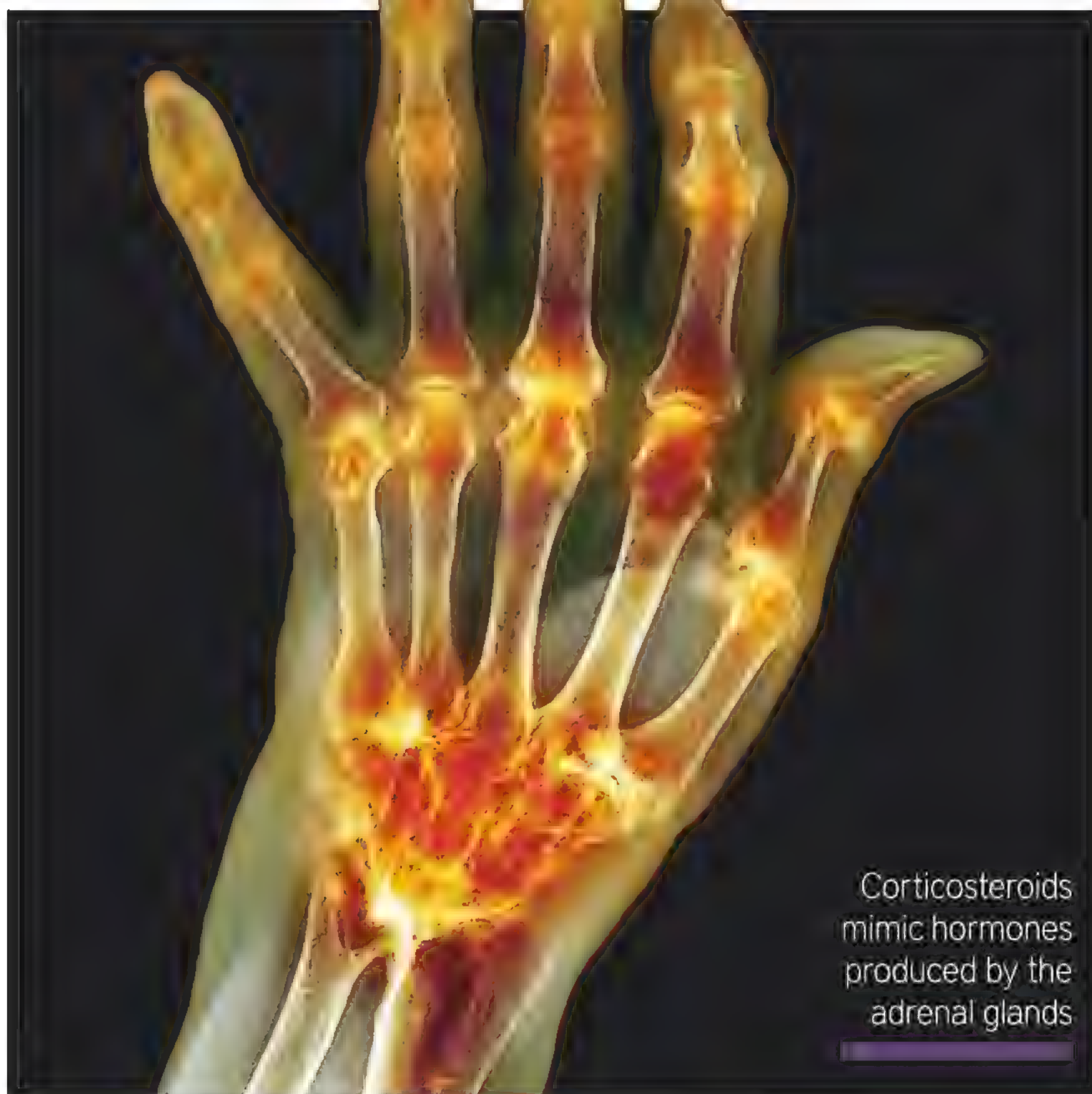
and euphoric effects of poppies have been familiar to many societies since around 4,000 BC; the modern medicinal use of morphine began shortly after it was first chemically isolated in the early 1800s.

Morphine can have severe side effects and can be both physically and psychologically addictive. Its use tends to be restricted to treating severe pain, such as the acute pain of serious injury, or the chronic pain and breathlessness of terminally ill patients.

DID YOU KNOW?

Just six countries account for 79 per cent of morphine use worldwide





Corticosteroids
mimic hormones
produced by the
adrenal glands

35 **The all-rounder**

Corticosteroids boast a plethora of benefits, easing the effects of everything from arthritis to asthma

CORTICOSTEROIDS ARE A family of medications that mimic the effects of hormones produced by the adrenal glands. They are anti-inflammatories and were first isolated in the 1930s; one, cortisone, was soon found to be a successful

treatment for rheumatoid arthritis. They have a wide range of effects in the body, including reducing inflammation and mediating the physiological response to stress.

Today, they are still used in the treatment of arthritis, along with

asthma, lupus, inflammatory bowel disease and chronic obstructive pulmonary disease, an umbrella term for a variety of lung diseases in which people have difficulty breathing. But their wide-ranging physiological effects also mean they can cause severe side effects such as high blood pressure, fluid retention and eye damage. Synthetic versions of the hormones have boosted the anti-inflammatory properties of the hormones while, in some cases, reducing the side effects.



36 Cutting clots

Although it doesn't actually thin blood, warfarin does reduce the risk of potentially fatal clots



WARFARIN'S DISCOVERY BEGAN with sick cattle in North America in the 1920s. Cattle were bleeding out either spontaneously or after minor procedures. It was found that their mouldy feed, made of sweet clover, was acting as an anticoagulant. The compound responsible, dicoumarol, was isolated in the 1940s, followed by more powerful derivatives. One of these, warfarin, was first marketed as a rat poison in 1948 and introduced for human use six years later; President Dwight Eisenhower was an early user.

Around 1 per cent of the UK adult population (8 per cent of those over 80) take warfarin to reduce the risk of blood clots developing or to halt the movement of clots to places such as the lungs. Despite being described as a 'blood thinner', warfarin actually works by interfering with the production of Vitamin K, an important component of the blood clotting process.

37 Furosemide

Also used on racehorses, this diuretic helps ease edema

FUROSEMIDE WAS THE first loop diuretic, so-called because it affects a part of the kidney called the 'loop of Henle'. The loop absorbs salt and water back into the blood after the kidneys have filtered it. Furosemide prevents the absorption of salt, in turn preventing water absorption and thus increasing the amount of urine produced.

Increasing the body's production of urine helps to relieve a condition called oedema, where fluid accumulates in the body. Furosemide can be used to treat this condition when it arises in cases of heart failure, where the lack of power in the heart's pumping action reduces

blood flow to the kidneys, which interpret this as the body needing more fluid. It also reduces blood pressure by lowering the volume of blood in the body.

Somewhat controversially, it is also used in some US states to

prevent racehorses from bleeding from the nose when racing. When it comes to human sport, however, athletes are banned from using the drug, as it is thought capable of masking the presence of other, potentially illegal drugs.



38

Ending the psychosis cycle

Chlorpromazine revolutionised the treatment of mental illness

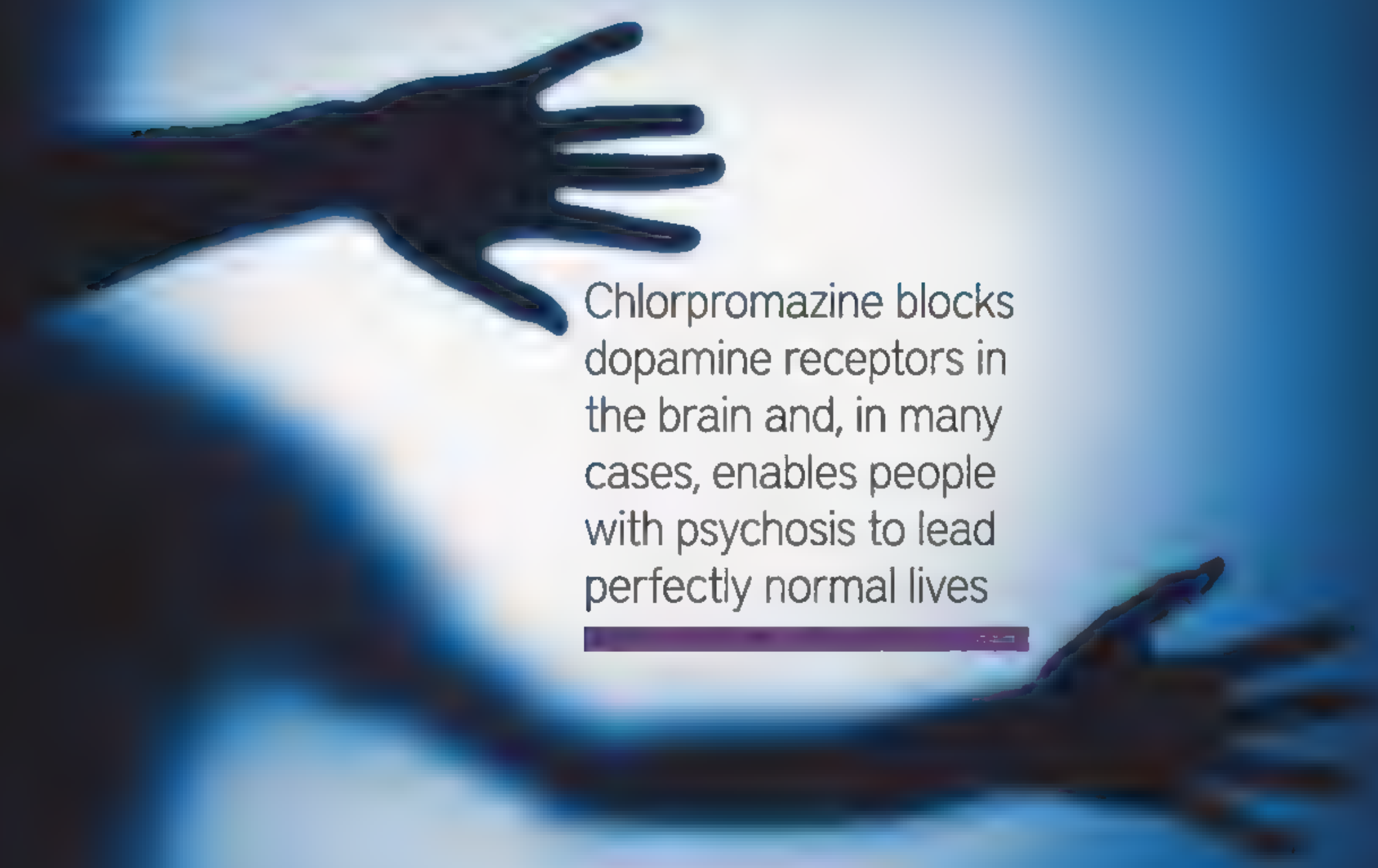
UNTIL THE 1950s, there were no drugs to treat mental illness. People with schizophrenia or other psychotic disorders were kept in institutions and treated with electroconvulsive therapy or talking therapies – with limited results.

This changed in 1952 when chlorpromazine, originally intended

to help treat shock in surgical patients, achieved astonishing results in psychotic patients in France. French psychiatrist Pierre Deniker encouraged its testing on patients in US state mental institutions, with similar results. The Food and Drug Administration approved the drug, marketed as

Thorazine, in 1954 and, within 25 years, the number of patients in residential psychiatric care dropped from more than 550,000 down to 150,000.

Chlorpromazine blocks dopamine receptors in the brain and, in many cases, enables people with psychosis to lead normal lives. While it does have side effects, such as increasing the chance of movement disorders, it opened the door to more advanced psychiatric medicines and is still used as the benchmark for psychosis treatments.



Chlorpromazine blocks dopamine receptors in the brain and, in many cases, enables people with psychosis to lead perfectly normal lives

39 **Strangely effective**

The story of the everyday – but still slightly mysterious – painkiller that is paracetamol

PARACETAMOL, KNOWN IN the US as acetaminophen, is a popular treatment for pain and fever. It is classed as a mild painkiller, suitable for headaches and other minor aches and pains, as well as for influenza. Strangely, for a drug we've taken for so long – it's been an over-the-counter medicine since 1956 – we still don't entirely understand how it works.

A forerunner drug, acetanilide, was introduced in 1886, but was found to be dangerous. A search for safer derivatives came across paracetamol, which was first

synthesized at Johns Hopkins University and tested on patients in 1887. But it was discarded in favour of a similar medicine called phenacetin; it wasn't until the late 1940s that researchers discovered that previous safety concerns about paracetamol lacked foundation – and that phenacetin is metabolised into paracetamol in the body anyway.

Paracetamol is one of the most widely used drugs in the world, but it is not entirely without risk – acute overdoses can cause fatal liver damage.



ALAMY / ISTOCK / SCIENCE PHOTO LIBRARY

40 **L-DOPA**

The anti-degenerative drug derived from fava beans

FIRST DISCOVERED IN fava beans in 1913, L-DOPA, or levodopa, is the mainstay of treatment for Parkinson's disease, a degenerative condition caused by a lack of the neurotransmitter dopamine. Like many drugs, levodopa is naturally produced by the body, but it wasn't until the 1950s that scientists began to realise its potential. It replaces the dopamine lost in Parkinson's, helping to control both motor and cognitive symptoms.

Dopamine itself can't cross the blood-brain barrier, but levodopa, as a precursor to dopamine, can and is converted into the neurotransmitter by an enzyme once in the central nervous system. While not a cure for the disease, it can vastly improve a sufferer's quality of life. But it's not without side effects, and can also lead to too much dopamine in the peripheral nervous system, meaning it must be administered in combination with other drugs.





41 **The transplant patient's saviour**

Cyclosporine reduces the threat of post-transplant infection

IN THE 1960S, surgeons were pioneering organ transplants, but patients often died because the strong immunosuppressant drugs needed to stop the organ from being rejected left them vulnerable to infection. Cyclosporine was the first drug that suppressed just one part

of the immune system – white blood cells called T cells – while leaving the rest to fight infection.

In 1969, a Swiss pharmaceutical company discovered cyclosporine in a soil sample that was brought back from Norway by a holidaying employee. The firm encouraged the

collection of such samples, in the hope of finding new fungal antibiotics. It didn't yield any antibiotics, but it did contain cyclosporine, a product of a fungus called *Tolypocladium inflatum*.

Cyclosporine took some tweaking; initially, investigators used high doses that caused kidney damage and tumours. The FDA approved it in 1983, and patients receiving organ transplants now take it indefinitely, in combination with steroids. It's also used to treat immune disorders such as psoriasis and rheumatoid arthritis.



42

Protease Inhibitors

Against HIV and more

SAQUINAVIR, THE FIRST protease inhibitor, is an example of purposeful 'structure-based drug design' – that is, creating a drug to do a particular job, rather than screening thousands to find one that might work. Protease inhibitors were invented to tackle HIV and after their introduction in 1995, they reduced the death toll from the virus in the US by 67 per cent in just a few years. They work by blocking the action of viral proteases, enzymes that chop up long HIV protein chains into the shorter proteins that the virus needs to mature and infect more cells.

Protease inhibitors are used in combination with other anti-HIV drugs in an effort to reduce the development of drug resistance, in the process changing HIV from a fatal, acute infection to a chronic, treatable disease. Protease inhibitors are also used by some doctors to treat malaria-causing parasites.

43 **Biting back**

Found in the sweet wormwood plant, artemisinin makes a strong contribution to the fight against malaria



TRADITIONAL CHINESE MEDICINE has known about the antimalarial properties of the sweet wormwood plant, or *Artemisia annua*, for 2,000 years, but modern medicine only caught on when Chinese researchers screened the plant as part of the mysteriously named Project 523 in 1967. They discovered artemisinin, found in the leaves of the plant, and news spread to the rest of the world in the late 1970s and early 1980s.

For decades, *Plasmodium falciparum*, the most common malaria-causing parasite, had been treated reliably with chloroquine and the combination drug

sulfadoxine/pyrimethamine. But growing resistance to the drugs led to dramatic increases in deaths in the 1980s and 1990s. Artemisinin combination therapies (combining a derivative of artemisinin with another antimalarial drug) were introduced in the late 1990s, and by 2006 were the World Health Organization's treatment of choice.

Deaths have dropped dramatically since their introduction, but the parasite is already showing signs of resistance in southeast Asia, in part because of inappropriate use of the drug.

Successfully used in traditional Chinese medicine, the sweet wormwood plant has provided protection from malaria for millennia



Despite Prozac's ubiquity, there has been controversy over its effectiveness in treating major depression

44 Prozac nation

Within a year of being on the market in the US, the antidepressant had been prescribed 2.5 million times

ALSO KNOWN BY its generic name fluoxetine, Prozac was discovered in the 1970s, the result of a search for drugs that would increase levels of the neurotransmitter serotonin in the brain, a lack of which was associated with depression. Fluoxetine was the first of the selective serotonin reuptake inhibitors (SSRIs), which work to

increase the amount of available serotonin in the brain. It was this specificity – as well as the fact that it had fewer side effects than other antidepressants – that helped to make it such a popular household name: by 1988, a year after Prozac was approved by the Food and Drug Administration, doctors in the US had issued 2,469,000 prescriptions.

45 Propranolol

The trailblazing beta blocker that scooped the Nobel Prize for Medicine for its creator

PROPRANOLOL WAS THE first successful beta blocker, a class of drugs used to treat a range of cardiac problems such as irregular heart beats, heart attacks and hypertension, or high blood pressure. Beta blockers prevent the action of hormones such as epinephrine, also known as adrenalin, making the heart beat more slowly and less powerfully, and thereby reducing blood pressure. The British scientist James Black was largely

responsible for developing propranolol in 1964. It quickly became a best-selling cardiac drug, earning Black the Nobel Prize for Medicine in 1988.

More specific drugs with fewer side effects have usurped propranolol in the treatment of hypertension in recent years, but it has found myriad other uses, from reducing anxiety and stage fright in performers to preventing migraines and treating glaucoma.

DID YOU KNOW?

There's a version of Prozac for dogs, called Reconcile, that eases separation anxiety

But Prozac does have side effects, including problems with both libido and sleeping. There has also been controversy over its effectiveness in the treatment of major depression and whether it helps mild-to-moderate depression whatsoever. It has also been associated with an increase in suicidal thoughts in adolescents and the under-25s.

ISTOCK / CORBIS



THE PIONEER



Edward Jenner

Born: 17 May, 1749, Berkeley, England
Died: 26 January, 1823, Berkeley, England

Known for:
Smallpox vaccination

EDWARD JENNER was a family doctor who performed a simple experiment that had worldwide consequences. In 1796, he took some pus from a sore on the hand of a local milkmaid and scratched it under the skin of a young boy, James Phipps. The sore, caused by 'cowpox', was known to offer protection from the then near-universal human disease smallpox. Phipps developed a sore and a slight fever from which he soon recovered. Jenner then placed some smallpox matter under Phipps's skin, 'inoculating' him, as was then done to mitigate the full-blown smallpox.

Jenner then tried the same procedure on others who had never had smallpox and showed that cowpox vaccine offered a much safer way to protect from smallpox. His initial paper being rejected, he privately published a small book in 1798 and several London doctors took up his ideas. The British parliament gave Jenner two generous grants, while Napoleon corresponded with him. Jenner's prediction that his method could eventually eradicate the disease finally came to fruition in the 1970s.

Jenner's innovation led to the eradication of smallpox by the 1970s

Alexander Fleming

Born: 6 August, 1881, Ayrshire, Scotland

Died: 11 May, 1955, London, England

Known for:
The discovery of penicillin

THE SON OF a Scottish farmer, Fleming studied at St Mary's Hospital Medical School in London, to which he was attached for the rest of his life. His mentor at St Mary's was Almroth Wright, known for his research on typhoid vaccine and his theories of immunity. Both Wright and Fleming sought to make scientific medicine available to Allied troops during World War I.

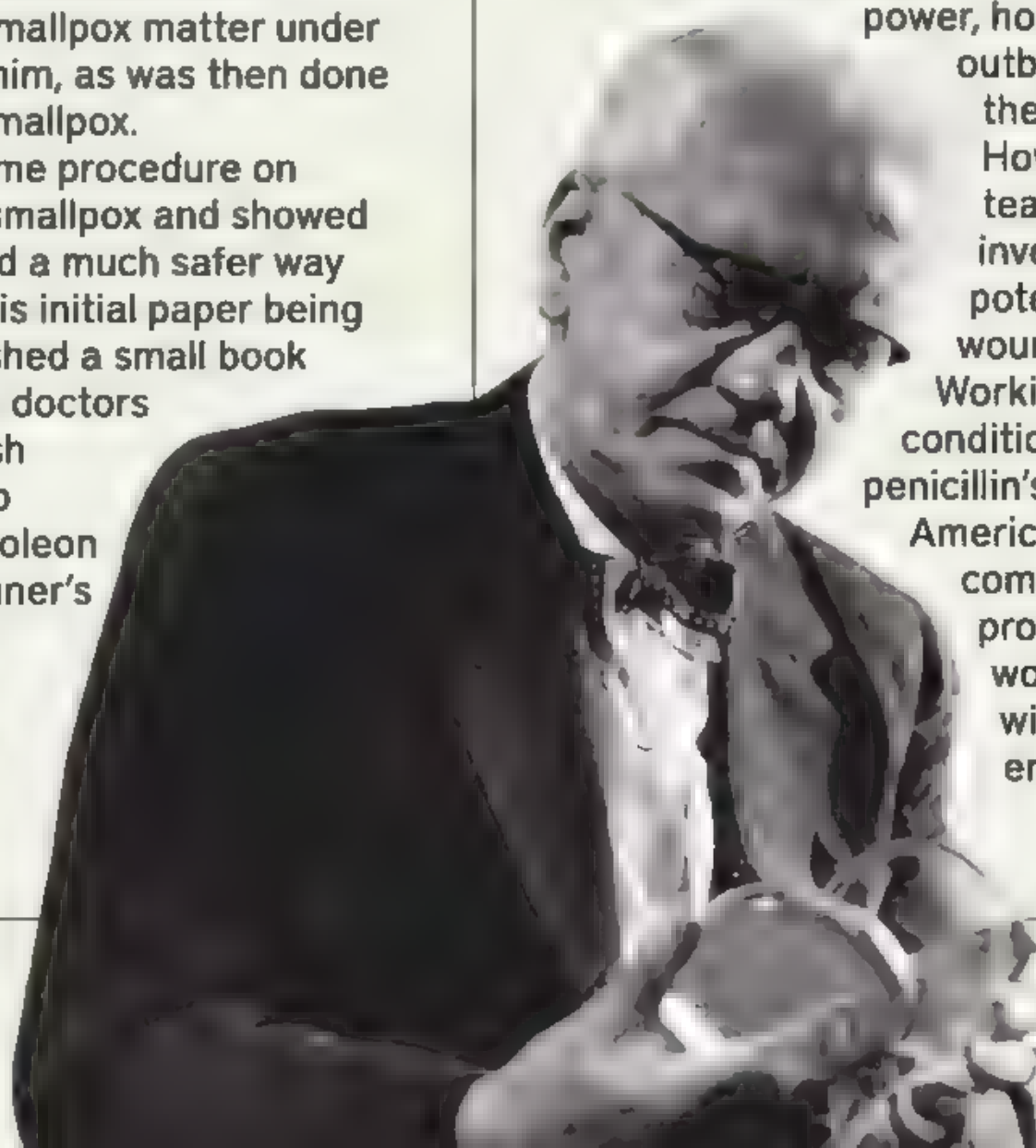
After military service, Fleming returned to the laboratory where he discovered lysozyme, a natural antibiotic occurring in tears, mucus and other bodily fluids. This prepared his mind for the unusual. Returning from a vacation, he noticed an area on a Petri dish with no bacteria growing. He investigated further and concluded that it had been caused by a spore of a fungus, *Penicillium notatum*, that had floated through an open window during his absence. These details have been challenged, but Fleming's investigations of 'penicillin', as he called it, established its antibiotic properties.

Fleming was unable to obtain sufficiently concentrated solutions to give penicillin clinical power, however. But with the

outbreak of World War II, the Oxford pathologist Howard Florey and his team were asked to investigate agents with potential uses in treating wounds and infections.

Working under tight wartime conditions, they proved penicillin's great promise.

American pharmaceutical companies scaled up production and the new wonder drug was more widely available by the end of the war.



ERS

FOUR VISIONARY SCIENTISTS WHO DEVOTED THEMSELVES TO DEVELOPING MEDICAL CURES



Frederick Grant Banting

Born: 14 November, 1891, Ontario, Canada

Died: 21 February, 1941, Newfoundland, Canada

Known for:

The application of insulin

FEW NOBEL PRIZES have been awarded so swiftly for a scientific discovery as that in 1923 to Banting and JJR Macleod for insulin; Banting and a medical student called Charles Best had only begun their research in May 1921. Macleod taught Banting, then an ambitious but frustrated surgeon and general practitioner, how to take out the pancreas of dogs. Although Banting knew what he wanted to do, he and Best floundered for several months, as the dogs on which they were experimenting kept dying, and they were unable to tie off the duct that channelled the products of the pancreas into the stomach.

Eventually learning how to collect the precious fluid, they needed help separating out the constituents; a biochemist, JB Collip, provided the expertise. The substance, named 'insulin', lowered blood sugar in dogs without their pancreas glands. Trials in children with diabetes, then a rapidly fatal disease, were dramatically successful. The children gained weight and energy, and were saved from their fate.

Although Banting was rightfully feted, he never followed up his insulin research. Insulin turned diabetes in children from an acute to a chronic disease, and so was actually a scientific management, rather than a cure.

Research began in May 1921. By 1923, he'd been awarded with the Nobel Prize

Gertrude B Elion

Born: 23 January, 1918, New York City

Died: 21 February, 1999, Chapel Hill, N Carolina

Known for:

Nobel Prize-winning drug research

GERTRUDE ELION WAS the daughter of Eastern European emigrants. She studied chemistry at Hunter College but, without money to pay for graduate school, she was forced to take a series of teaching jobs and went to secretarial school. But World War II proved to be a blessing, since there was a sudden shortage of research scientists. She accepted a position with George Hitchings, with whom she later shared a Nobel Prize.

Hitchings worked for the pharmaceutical company Burroughs Wellcome, and Elion specialised in synthesizing a class of organic compounds called purines; she provided the chemicals for testing for their pharmacological actions. A notable early success was an important cancer drug called 6-mercaptopurine (Purinethol). This was followed by a string of major drug discoveries, including those useful in treating gout, malaria and herpes virus, along with those used in organ transplantation. Few scientists have been involved in such an impressive list; her group also later developed the first effective drug against the AIDS virus, known as AZT.



MIND & WE

EASY STEPS TO IMPROVE YOUR OUTLOOK ON LIFE

- + Can your **SOCIAL NETWORK** improve your health?
- + Do **CROSSWORDS** guard against Alzheimer's?
- + Is **LAUGHTER** really the best medicine?
- + How can **VOLUNTARY WORK** make you healthier?
- + Does a **HAPPY MARRIAGE** improve life expectancy?
- + Will **OWNING A PET** give you a happy heart?

ILL-BEING



46 Occasional indulgence

Enjoying the odd treat is good for your health, so total abstinence isn't actually the wisest option

GUILT INCREASES THE levels of cortisol – the stress hormone – in our bodies. But people who feel less guilt while doing pleasurable things have higher levels of immunoglobulin A, which helps the body fight illness. So doing what we enjoy, whether that's a trip to the movies, a glass of wine or a glass of wine, can reduce stress – as long as we elude the guilt that goes along with a treat.

A good example is dieting. A 2014 Cornell University study found dieters who incorporated 'cheat days' into their diet lost weight overall. In fact, even though they may have indulged

in a burger and fries on the weekend, they resumed their diet come Monday. Brian Wansink says: 'Some indulging during weekends makes it easier to have a healthy diet. It's important to take steps to reverse the downward trends after the weekend.'



47 Stimulate your brain

Keep those brain cells active

IT'S IMPORTANT TO keep your mind sharp if you want to enjoy your longevity, as research from Rush Alzheimer's Disease Center and Rush Institute for Healthy Aging in Chicago shows.

Their study, published in the *Journal of the American Medical Association*, looked at 800 older adults from across the USA over an average period of 4.5 years. They found that the more often people took part in mentally stimulating activities, the less likely they were to develop Alzheimer's disease. People who challenged themselves cognitively several times a week had a 33 per cent lower risk of Alzheimer's disease than people who took part in brain-

TOP TIP

As well as reading, doing puzzles and playing cards, why not enrol in a class at a community college in order to stay mentally sharp?

stimulating activities just a few times a month. And you don't have to be a complete brainbox to reap the benefits, either: simple yet mentally demanding activities – like reading, playing cards, doing crosswords and puzzles or visiting museums – all reduced the risk of Alzheimer's disease.





48 **Don't get down, get counselling**

Talking it out can drive away depression

THE NUMBER OF people with depression in the US is on the rise. According to National Health Service estimates, around 10 per cent of UK adults will experience symptoms of depression at some point in their lives, while the number of people with depression increases by about 20 per cent every year.

Patients are most often prescribed antidepressants, but a type of psychotherapy called cognitive

behavioural therapy (CBT) is another strong option. UK researchers weighed up the results of 63 trials of people with depression who had 10-20 brief sessions of CBT, either on its own or in addition to drug treatments. Compared to those receiving drug treatment alone, patients who had CBT were significantly more likely to improve to the point where they were no longer considered clinically depressed.

According to NHS estimates, around 10 per cent of UK adults will experience depression at some point in their lives

49

The social network

Your relationships with friends and family can determine your long-term health

TO HELP MAINTAIN a strong sense of well-being, it's worth thinking about who you choose to spend your precious free time with. As our social relationships can affect our health and death risk, remember to keep your enemies close but your friends even closer. Several studies have linked poor social ties with poorer outcomes in people who already have heart disease, dementia, high blood pressure, depression and cancer.

For example, a study led by Dr Beverley Brummett from Duke University School of Medicine in Durham, North Carolina, found that – among adults with coronary artery disease – people with three or fewer people in their social network had more than double the risk of death from heart disease than their more socially connected peers.

There are also direct links between loneliness and dying early in healthy people. A nine-year study of 6,928 adults in Alameda County, California, showed that those with fewest social ties were more than twice as likely to die during the study as people with the most social ties – even after socioeconomic status and health behaviours were taken into account.

The Alameda County study was conducted during the 1970s, but remains resonant. Even though we are more connected today through mobile phones, the internet and social media, researchers at the University of Texas at Austin say a “confluence of smaller families, high divorce rates, employment-related geographical mobility, and population ageing” is likely to increase feelings of social isolation.

Social isolation is more than simply an emotional experience and doesn't just mean being or living



alone. A global study of more than 300,000 people that was published in 2010 discovered that people with stronger social relationships had a 50 per cent higher chance of outliving those with weaker

social relationships. The authors estimated that having few social connections to friends and family is a risk factor for early death that's comparable to smoking 15 cigarettes a day – and actually worse for us



than factors such as obesity and physical inactivity.

But social isolation clearly isn't linked to relationship status in any straightforward fashion, as in the global study people who were single

or widowed didn't necessarily die earlier than people who had partners. Lead researcher Julianne Holt-Lunstad, from Brigham Young University in Utah thinks quality, rather than quantity, is key to getting

the most benefits from our social ties – and so we should focus on boosting our strongest relationships. “We need to pay better attention to naturally occurring relationships and to fostering those.”



50

Free your mind

Science is waking up to the physiological and psychological benefits of meditation

MEDITATION ENCOURAGES US to reduce our stress levels by teaching relaxation techniques and ways to unlearn the habits that encourage us to 'hold tension'. In recent years, meditation has been attracting scientific interest for its potential stress-relieving effects on the mind and body, along with its health benefits, particularly in the field of psychiatry, where there's evidence that it can help people with anxiety.

Researchers in Thailand, where meditation is a common Buddhist

practice, studied people in the US who had anxiety. They found that those who followed an 18-week course of transcendental meditation – a technique that allows the activity of the mind to settle down into a state of profound relaxation while remaining wide awake – felt less situational anxiety, and were less distressed by their symptoms, after learning how to meditate. They also felt better in social situations at work, as well as in their relationships with friends and family.

TOP TIP

Meditation works best when it becomes a formal part of your day and is given a regular slot in your schedule



A person is captured mid-jump over a metal railing, with their arms raised in a 'V' shape, symbolizing positivity. They are wearing a dark jacket, a plaid shirt, and light-colored pants. The background is a bright, slightly hazy sky.

51

View your glass as half-full

Optimism reduces stress hormones

A POSITIVE OUTLOOK can affect your health. This is probably due to lower levels of the stress hormone cortisol, but positive people are probably also more likely to live healthier lifestyles.

Perception is a key part of effective stress management. In 2012, an eight-year University of Wisconsin study of 30,000 Americans found that those with a lot of stress had a 43 per cent increased risk of dying early – but only if they viewed their stress negatively. Having a positive outlook doesn't mean burying your head in the sand or denying that unpleasant situations happen: learning

positive thinking skills simply means you're better able to handle everyday stress in a more constructive way.

Experts at Minnesota's Mayo Clinic say that the health benefits of a positive outlook also include lower rates of depression, greater resistance to the common cold and a reduced risk of death from heart disease.



53

Get outdoors

Is exercise in the fresh air better than taking tablets?

EXERCISE OFFERS MANY benefits to the mind. It boosts hormones, such as endorphins and serotonin; it provides precious time away from our daily routine; and it gives us a chance to spend a while outside in the fresh air or playing social sports with friends. It therefore makes perfect sense that regular, outdoor exercise has a positive effect on our mood and is now a recognised way to improve the symptoms of depression.

The best evidence comes from a review carried out by a team of UK researchers and published in

52 See the funny side

How smiling and laughing can lower stress levels

A GOOD SENSE of humour helps you maintain a positive outlook on life, and could improve your well-being. Psychology researchers have shown that people have a lower heart rate and faster stress recovery if they smile while under stress. But this only works if you flash a genuine, or 'Duchenne', smile, named after the 19th-Century French neurologist who first described it. "The muscle activity involved in a smile sends a message to the brain signalling safety, which could translate into

lower heart rate and stress levels," says Dr Sarah Pressman, an assistant psychology professor at University of California, Irvine.

Don't stop at just a smile, though. Science shows there are benefits to be derived from a hearty laugh, too. Research published in the *British Journal of Psychiatry*, based on a study of more than 500 people including students and people with health problems, found that a sense of humour is linked with feelings of better health.

More than 2,000 people with depression found exercise to be as effective a treatment as antidepressants

the *Cochrane Database of Systematic Reviews*, that looked at 37 studies that compared exercise with a placebo, medication or psychological counselling. Across this research, more than 2,000 people with depression found exercise to be as effective as antidepressants and psychological therapies for reducing the symptoms of depression. However, researchers note that there needs to be more detailed research looking at what types of exercise are most helpful for depression, as well as the number and duration of sessions that would help the most.



54 Yoga

Embrace its undeniable calming qualities

A SEDENTARY LIFESTYLE and stress are major risk factors for several conditions. Since yoga involves stretching, flexibility and deep breathing techniques, its calming effects are thought to reduce pain as well as helping some stress-related conditions.

Several small trials have found that yoga reduces the intensity and frequency of migraine and reduces labour pain. A Dutch review of 37 studies of the benefits of yoga in 3,000 people, published in the *European Journal of Preventive Cardiology*, found that compared to no exercise, yoga had significant benefits and was linked to a lower risk of obesity, high blood pressure

and raised cholesterol. And a research team from the UK-based Cochrane Collaboration – a body that evaluates research on medical treatments – found yoga can reduce diastolic blood pressure and lipids in the blood called triglycerides, while raising levels of ‘good’ HDL cholesterol.

TOP TIP

The word ‘yoga’ first appeared around 400BC in a Hindu text called the *Katha Upanishad*

55

Take a deep breath

How finding time to practise deep breathing can have important physiological effects

RESEARCHERS BEGAN STUDYING the benefits of the relaxation response – the state of deep rest induced by using the diaphragm muscles at the base of the lungs to take long, deep breaths – in the 1970s. Since then, researchers have found it helps reduce symptoms of anxiety, lowers heart rate and blood pressure, and improves oxygen exchange.

Research from Harvard Medical School identified for the first time how these benefits might be induced. Their study of 26 healthy

people found practising deep breathing 20 minutes a day for eight weeks increased the expression of genes involved in energy release, as well as the NF-B protein, which is part of the body's response to inflammation, stress and trauma. Manoj Bhasin, assistant professor of medicine at Harvard Medical School, concludes that "people have been engaging in these practices for thousands of years, and our finding gives greater credibility to what some have called 'new age medicine'."



56

Don't fear rejection

Can social pressures affect the immune system?

THE EMERGING FIELD of psychoneuroimmunology studies the relationship between stress, the immune system and our health. Take the relationship between personality factors and the progression of HIV. Dr Steve Cole, of the University of California, Los Angeles, studied why HIV-positive gay men in LA who hide their sexual orientation tend to become ill more quickly than their out, HIV-positive peers. Cole's theory is that closeted men share nervous system characteristics that render them especially sensitive to social rejection, which may make them more vulnerable to attack by the HIV virus. If they fear rejection, it may affect their immune system, making them more susceptible to illness.



57

Happy couple

Marriage's health advantages

RESEARCH SHOWS HOW marriages and civil partnerships shape our health. The US National Health Interview Survey polled 789,000 people and showed that healthy, unmarried people who rated themselves as in 'excellent' health were on average 75 per cent more likely to die during the 20-year study than married people. People in same-sex relationships were also in better health than single gay people.

But the benefits declined as people's health, or marriages, declined. Unmarried people in 'fair' health were only 40 per cent more likely to die than married people.



And research by the American Psychological Association found that couples who later divorced had 34 per cent higher levels of the stress hormone norepinephrine than couples who stayed married.

Professor Janet Kiecolt-Glaser, from the Institute for Behavioral

Medicine Research at Ohio State University agrees, confirming that "marital quality is a good predictor of subsequent health. These findings show us in a microcosm how close personal relationships can get translated into health outcomes."



58 Consider relocating

Swapping the city for the country has been proven to offer genuine benefits to mental health

GARDENS AND GREEN space can significantly improve well-being and quality of life, according to the European Centre for the Environment and Human Health.

The data – from a large sample of adults who moved between urban

and greener areas in the UK over a 17-year period – showed that people had less mental distress and higher life satisfaction when they lived in greener areas, even after accounting for factors that influence mental health.

On average, people who moved to greener areas experienced an immediate improvement in their mental health that lasted for at least three years afterwards. At the same time, the mental health of people who relocated to more urbanised areas declined.

Dr Matthew White from the ECEHH explains that the benefits for the individual are notable – “roughly equal to a third of the impact of being married and a tenth of being employed” – but could also be significant if scaled-up to society as a whole.

59 Don't bottle it up – write it down

Picking up a pen can act as a highly effective pressure valve

THE SEMINAL WORK *Writing To Heal*, by social psychologist James W Pennebaker, established that writing about our experiences can improve our health and psychological well-being. It can improve sleep, reduce stress-related doctor visits and boost immune cell activity. Furthermore, it can also speed healing after surgery and even improve self-rated mental and physical health in cancer patients.

It's not just what you write about, but how and how often that counts. Studies suggest that writing daily

helps, as does *reflecting* on your feelings – not just describing them. Studies have found that writing about negative events, using lots of 'cause and insight' words like 'hence', 'because' and 'therefore' helps create a more coherent narrative from stressful memories. Researchers suggest that "at least for fairly minor life problems, something as simple as writing about the problem for 20 minutes [a day] can yield important effects in terms of physical health and mental health".



60 Banish self-blame

Half the onset of depression by reversing those 'not thoughts'

WORK BY DR Margaret Kemeny at the University of California, San Francisco suggests that blaming one's self for negative events affects the immune system and is linked to poorer health outcomes. This is because, Kemeny says, "the body responds to what's going on in the brain, not to what's going on in the environment".

Dr Geoffrey Reed of the American Psychological Association says this finding is pioneering. "We're suggesting that there may

be something about cognitive processes that has a direct effect on the immune system. Being optimistic may actually be healthy."

The benefits can be seen from studying the factors that can contribute to depressive illnesses, as negative thinking (or 'cognitive vulnerability') increases the risk of depression. According to research from Case Western Reserve University in Cleveland, Ohio, reversing negative thoughts can help prevent serious depression.

Research suggests that cognitive processes may have a direct effect on the immune system



61 **Responding to stress**

Negativity needn't necessarily be your automatic reaction to stressful situations. Think positively!

THE HUMAN BODY has evolved to trigger responses to help you deal with stress and to protect your body from its potentially harmful effects. We often associate the effects of this 'stress response' with negative experiences, but don't make that your go-to reaction. "Changing the way people think about stress can

go a long way to helping them respond better," argues Dr Jeremy Jamieson, assistant professor of psychology at the University of Rochester, New York.

Jamieson asked volunteers to perform stressful tasks after being given information encouraging them to "reinterpret bodily signals as

beneficial", while other volunteers weren't given this information. The results? The group prepped with the message performed better and had less social anxiety. Rethinking how we and those around us feel about stress can dramatically alter how effectively we cope with stressful situations and major life transitions.



62

Reap the placebo effect of exercise*Think yourself fitter...*

YOUR MINDSET - WHAT you *think* about how much you exercise and how valuable it is to your health ÷ could change your physiology and behaviour in ways that could lead to real gains in health.

In a study of 84 female hotel workers, the results of which were published in the journal *Psychological Science*, some of the group were informed that the work they do is good exercise and satisfies the Surgeon General's recommendations for an active lifestyle; the rest of the group was not given this information.

Although their actual behaviour did not change, four weeks after the study started, the informed group perceived themselves to be getting significantly more exercise than before. And what's more, compared with the control group, they showed a decrease in weight, blood pressure, body fat, waist-to-hip ratio and body mass index. So simply by reminding yourself how active you actually are, you could reap the benefits gained from exercise.

Studies show that simply by reminding yourself how active you actually are, you could reap more of the benefits gained from exercise

63 Get a pet

At the very least, bringing a dog into your life provides health benefits from all that exercise

WHETHER DOGS, CATS, rabbits or birds, pets are believed to have a range of health benefits for their owners. Pet dogs have been studied the most, with some research suggesting dogs can provide early warnings for cancer, oncoming seizures and high blood sugar.

There's evidence, too, that pet owners as a group are healthier than non-pet owners, but it's hard to be sure whether these benefits are due to pet ownership or to the related upsides that happen to be

good for our health. Here's an example: a study published in the *Medical Journal of Australia* in 1992 found that dog owners have a healthier heart profile than non-dog owners. Is that because they were dog owners, though? Or is it simply because they exercised more regularly from walking their dogs?

As scientific attention increasingly turns to the relationship between pets and the well-being of their human friends, we should get some answers.





64

Lend a helping hand

Why not volunteer?

THE GREEK PHILOSOPHER Aristotle said that the purpose of life is “to serve others and do good”. And lending a helping hand is indeed good for our health, according to a study by Carnegie Mellon University in Pittsburgh. Adults over the age of 50 who volunteered for 100-200 hours a year had lower blood pressure than those who didn’t. High blood pressure has been linked to an increased chance of heart disease and strokes, so some researchers

believe volunteering could be linked to a longer lifespan.

It’s not a cause-and-effect relationship, but health psychologists believe volunteering increases physical activity, which could improve unhealthy heart profiles. But it’s important to volunteer for the right reasons and not for its health benefits. A study published in *Health Psychology* found that people who volunteered lived longer – but only if their intentions were truly altruistic.



People over the age of 50 who volunteer for 100-200 hours a year have lower blood pressure than those who don't

65 Jealous mind

Avoid becoming the green-eyed monster

JEALOUSY CAN HAVE weird effects on the brain. Harboursing jealous or insecure thoughts, like imagining your partner with a new lover or comparing your résumé to that of a workplace rival, kicks the amygdala – a part of the brain involved in our perceptions of fear, anger and disgust – into gear. At least, so say neuroscientists at Kyoto University in Japan.

The threat of a challenger who could leave you jobless – or single – activates a fear reaction in the

amygdala, triggering the release of the hormones adrenaline and noradrenaline. This is your body's way of preparing to deal with challenges and threats. But it can make the nervous system buckle under the stress of jealousy and cause blood pressure spikes, which have been linked to some forms of dementia.

A study of 800 women over 38 years found that those women who felt the most stressed or anxious were at increased risk of Alzheimer's disease and long-term distress.



THE PIONEER

Sigmund Freud

Born: 6 May, 1856, Freiberg, Austria
Died: 23 September, 1939, London, England

Known for:
Inventing psychoanalysis

SIGMUND FREUD'S ADORING mother was an important early influence on him, encouraging his intellectual development and aiming for a career in medicine. He studied at the University of Vienna, where he worked in neuroanatomy and neurophysiology, before swapping research for clinical practice. To that end, he studied in Paris with the neurologist Jean-Martin Charcot, who was particularly fascinated by hysteria and the medical uses of hypnosis.

Freud eventually abandoned hypnosis in favour of free association, where his patients said whatever came into their minds. This would, Freud argued, unblock the repressed memories that caused their neuroses. Using his own self-analysis as a guide, Freud developed his therapeutic methods. His insistence on the sexuality of infants was unpopular, although his awareness of 'transference' (the feelings that develop between therapist and patient) showed great insight. He went on to produce a rich cultural map of the mind, delving into the meaning of dreams, jokes and slips of the tongue, along with the relationships between what he called the ego, superego and unconscious. He later turned his attention to the origins of religious beliefs and the dark forces of repressive civilisation.



Hans Selye

Born: 26 January, 1907, Vienna, Austria
Died: 16 October, 1982, Montreal, Canada

Known for:
Highlighting the role of stress

SELYE WAS A SELF-MOTIVATED man, receiving his medical education in Prague, Paris and Rome, before postgraduate work at Johns Hopkins in Baltimore and McGill in Montreal.

Selye's early research focused on the problems famously set out by the Harvard physiologist WB Cannon. Cannon studied the 'fight or flight' response of an animal to danger or external stresses. These include increased heart rate, as well as changes to breathing, pupil size and blood pressure. Selye argued that they are (in part) the consequence of an outpouring of adrenalin from the adrenal glands. Cannon believed that these responses had evolved over millions of years.

Selye argued that stress is not simply an external stimulus, but in human beings has an internal dimension (we feel it). He identified three phases in the reaction: an 'alarm' state, a phase of adaptation and, if the stress continues, a phase of exhaustion. This model laid the basis for much human illness, including high blood pressure, ulcers and heart disease. He shared his findings to the public through lectures and books, and continued to investigate the physiological mechanisms accompanying stress. Although later researchers have modified many of Selye's insights, stress disorders are still counted among the burdens of modernity.

Selye argued that stress is not simply an external stimulus

ERS

FOUR FREE-THINKERS WHO TOOK BRAVE NEW APPROACHES TO IMPROVE MIND AND WELL-BEING

BKS Iyengar

Born: 14 December, 1918, Bellur, India

Died: 20 August, 2014, Pune, India

Known for:

Being the father of modern yoga

YOGA IS AN ancient Indian spiritual and physical discipline that was codified in about 200 BCE by a Hindu sage named Patanjali. It has since branched out into several different disciplines, each following its own set of eight stages, five external and three internal, which Iyengar called ashtanga yoga.

Practised by millions across the world, yoga owes much of its popularity to BKS Iyengar, who learned the techniques from a brother-in-law to whom he was sent by his family after a sickly childhood. Iyengar then became a practitioner and teacher, eventually founding the BKS Iyengar Ashram in Pune in 1966. Yehudi Menuhin met Iyengar in Bombay (now Mumbai) and henceforth practised yoga, insisting that it improved his violin playing. This greatly enhanced Iyengar's status abroad.

Although he became an object of veneration, Iyengar maintained his dignity and his concern that yoga retain its primarily spiritual status. However, both the postures and the breathing

techniques he developed helped to maintain muscular suppleness, lower blood pressure and increase mental and physical well-being. Iyengar stressed that his system does not place the strains on the heart that more violent forms of exercise do, making it suitable for people of all ages and states of health.



Aaron Temkin Beck

Born: 18 July, 1921, Providence, Rhode Island

Known for:

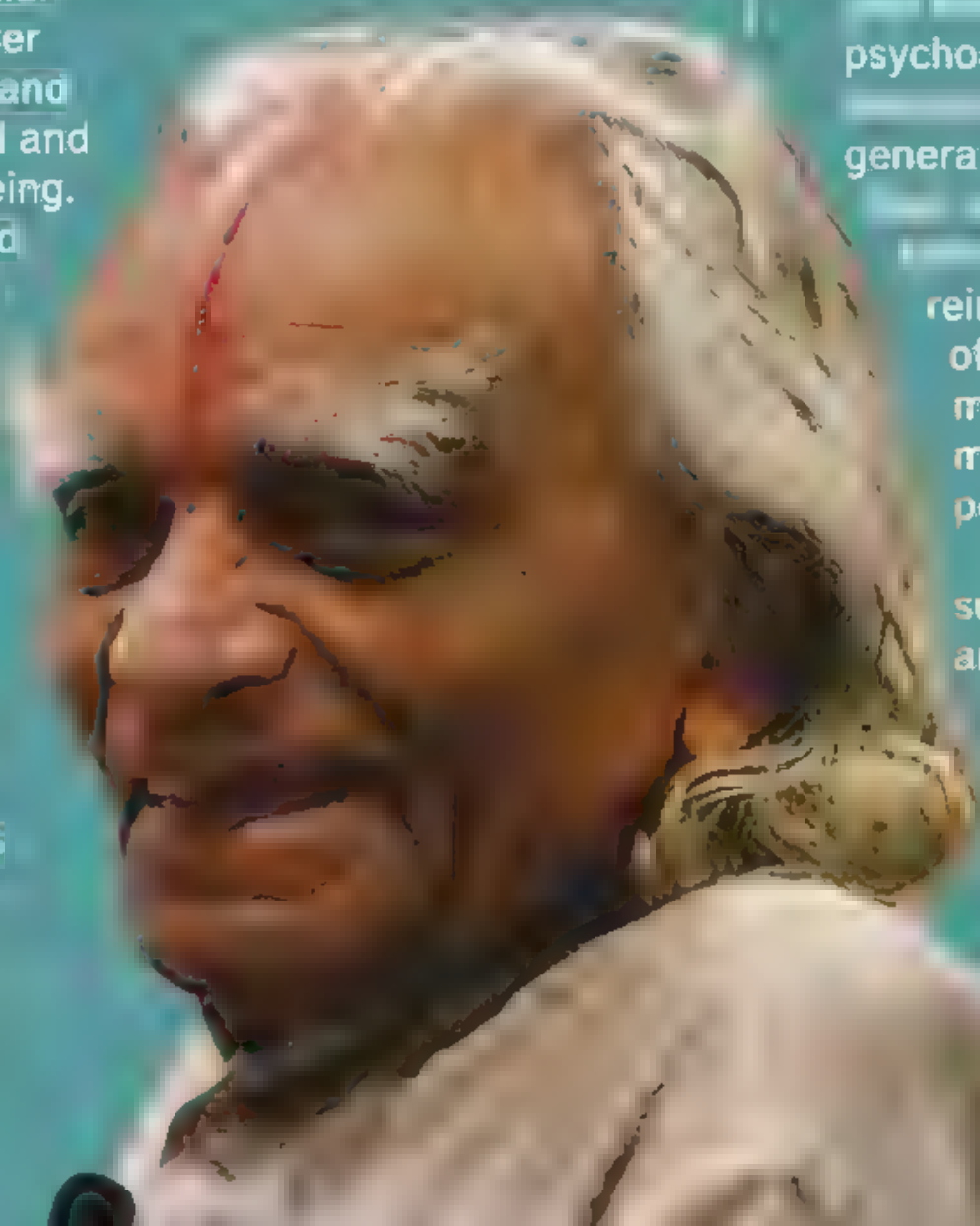
The development of cognitive therapy

BEHAVIOURISM, EXPLAINING BOTH behaviour and learning, dates from the 1920s and has been applied to patients for almost as long. Cognitive therapy (CT) and cognitive behavioural therapy (CBT) evolved from within this tradition, whose central figure is Aaron Beck.

Beck graduated in medicine from Yale University in 1946 and was a practising psychoanalyst for some years. But, when comparing the outcomes of various psychoanalytic techniques with those of CBT, Beck noticed that many patients had generally negative forebodings about themselves, but were unwilling to accept them. Instead, they would reinterpret patients' comments (as analysts often do), Beck took them at face value. "No matter how complicated a patient's problem may be," he said, "a therapist has it in his power to make it even more complicated."

Beck's CBT methods have been very successful in treating depression, but are also used in treating anorexia, drug dependence, anxiety and phobias. He has founded both a non-profit institute and an academic journal, both devoted to promoting research and disseminating information to the reading public.

Beck is the central figure in cognitive therapy







MEDICAL ADVANCES

THE LATEST RESEARCH FROM THE LABORATORY

- + Can medication bring patients **OUT OF COMAS**?
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- + Will **SMARTPHONES** be able to make medical diagnoses?
- + Is **PERSONALISED MEDICINE** really possible?
- + How far away is an effective **HIV VACCINE**?
- + Is **BIONIC EYESIGHT** just an invention of science fiction? ...

66 Medical nanotechnology

Progress at an extraordinarily microscopic level

TINY ROBOTS HUNTING down and destroying tumours in the body, or microscopic detectors monitoring blood sugar levels in diabetics, might sound like the stuff of science fiction. But they're likely to become reality in the next few years, as nanotechnology revolutionises how we detect and treat disease.

Nanotechnology is the manipulation of matter at the scale of atoms and molecules. One of the leaders of the medical nanorevolution is Professor Sylvian Martel, director of the NanoRobotics Lab at École Polytechnique de Montreal, who is developing nanotechnology that delivers chemotherapy drug payloads directly to cancers, rather than the drugs roaming freely throughout the body, damaging healthy cells. Martel's 'magnetic microcarriers' are just 50 micrometres in size and consist of magnetic nanoparticles and drugs encased in a biodegradable polymer sac. These would be steered through blood vessels using the magnetic fields generated by MRI machines until they reach a cancer, where the drug payload will be released. "There are many problems to solve and medical trials to do," says Martel, "but I believe the world will start to see cancer-fighting robots on the market within the next decade."

Other microbots are also in development. At the Swiss Federal Institute of Technology in Zurich, Professor Brad Nelson is working on 'steerable surgeons' – tiny nickel constructions fashioned into a 3D tool powered through the body by external magnets. His plan is to use them to carry out surgery on the

retina in the eye. Meanwhile, the 'plaque busters' developed by Dr Jong-Oh Park at Chonnam National University in South Korea consist of magnetic capsules and micro drill heads. Again powered by magnets, they scour the arteries, removing the plaque that might otherwise clog the vessels as they go.

Nanotechnology is proving a particularly active area of research for the treatment of diabetes. At Vanderbilt University in Tennessee, scientists are developing a

Nanotechnology – the manipulation of matter at the scale of atoms and molecules – is very active in the treatment of diabetes

'microphysiometer' that can accurately measure insulin levels. This sensor is packed with carbon nanotubes – tube-shaped carbon molecules – and when insulin levels rise, so does the current within the nanotubes. The researchers

envisage that the sensor would quietly monitor insulin levels in the body in real time, freeing diabetics from the need to carry out blood tests throughout the day.

Several teams around the world are also investigating using nanotechnology to enable insulin to be taken orally, rather than by injection. The insulin would be loaded into tough nanoparticles able to withstand the harsh conditions of the digestive system, and the particles coated in a material such as chitosan that would make them easily absorbed by the small intestine, so the insulin can be delivered to the bloodstream.

Other medical nanotechnology ideas in development include nanorobots that can repair damaged cells, and nanotube-coated lenses that convert light to sound waves and could be used as an 'invisible knife' for surgery.





67

Real-life tricorder

The easy way to self-test

HANDHELD DEVICES THAT can diagnose several medical conditions, like the 'tricorders' on *Star Trek*, are coming of age. Among the most developed is the Scout, from Silicon Valley-based Scanadu. Place one of these small sensor-packed devices on the forehead and it can detect vital signs such as body temperature, blood oxygen, heart rate and blood pressure. The data is then stored on a smartphone app, so patients can monitor their health and share it with their doctor.

Other systems include ScanNurse, which can diagnose ear and throat conditions from photographs, and the QuantuMDx Q-POC, which uses interchangeable

cartridges to scan for different conditions. Both were developed in the UK.

The Qualcomm Tricorder X Prize, launched in 2013, challenges participants to develop a device that can detect 16 conditions, offering \$10m in funding as a prize. The winners will be announced in 2016.

68 Waking up comatose patients

How sleeping medication could bring people out of comas

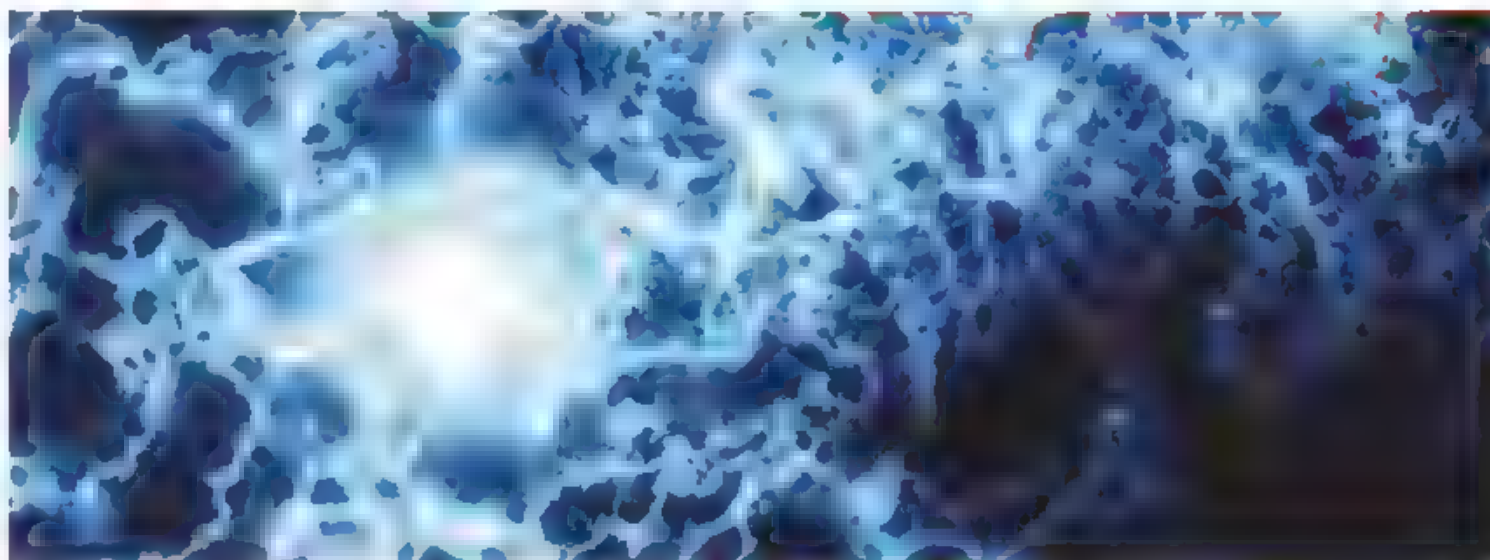
IN THE FUTURE, patients may be 'awakened' from a semi-comatose state using, paradoxically, sleeping drugs. Over the past decade, there have been sporadic reports of patients recovering at least partial consciousness after being given sleeping pills such as Ambien, which contain the hypnotic drug zolpidem.

At Weill Cornell Medical College in New York City, neuroscientists measured the electrical activity in the brains of three people who have been 'awakened' with Ambien. Despite being brain damaged in different ways, the patients' electroencephalograms (EEGs) all showed the same thing. Before taking the drug, they had low frequency waves in their EEG readings, but when the drug was taken, there was a fast wave of excitation in their brain cells that

continued for some time, allowing the patients to become more awake. One even spoke fluently as a result.

The pre-drug brain activity suggests a 'resting reserve' of brain activity that can be harnessed, say researchers. "The idea is that hopefully we can screen other patients with EEG to find out if they also have a reserve," explains research leader Dr Nicholas Schiff.

Three brain-damaged patients were 'awakened' with Ambien. After taking the drug, one of them even spoke fluently



69 Through the keyhole

Could open surgery be replaced by the laparoscope?

KEYHOLE – OTHERWISE KNOWN as 'laparoscopic' – surgery has been around for a long time: the first human operation took place in Sweden in 1910. But the practice rapidly grew in use in the 1980s and, as new techniques are developed, it will become even more common.

In laparoscopy, a surgeon is able to access the abdomen and pelvis without having to make large incisions in the skin. The laparoscope

DID YOU KNOW?

The first laparoscopic operation was performed in Germany in 1902 – on a dog

– a small tube fitted with a light source and camera – is inserted via small incisions in the abdomen, along with specialised surgical instruments. The laparoscope is used to pump gas into the abdomen, making it easier for the surgeon to operate.

At the cutting edge of laparoscopy is Professor Bjørn Edwin from the University of Oslo and Oslo University Hospital in Norway. In 2014, he announced that he had developed a laparoscopic technique to remove cancer that's spread to the liver from the intestine. In traditional surgery, half the liver is removed, but Edwin removes just small sections, which means that further surgery can be carried out if the cancer returns. "Laparoscopy will increasingly replace open surgery," predicts Edwin.



70 Precision engineering

The dexterity of robot surgery means less invasive procedures when treating severe epilepsy



DREAMTIME/JOE DAVID GOMBE, VANDERBILT UNIVERSITY

TREATING THE MOST severe cases of epilepsy currently involves invasive surgery, going through the skull and deep into the brain to destroy the neurons that are the source of the fits. But a new robot has been developed that's so agile it can navigate its way to the brain from a patient's cheek, disturbing much less of the brain.

Neuroscientists currently enter the brain through the cheek when implanting electrodes that can pinpoint the spot in the hippocampus where epileptic seizures originate. But the needles they use to destroy the problematic nerve cells are straight, so the only route is through the skull. The robotic surgeon developed at Vanderbilt University in

Nashville, however, uses a needle that can follow a curved path into the hippocampus. The needle is built from nickel-titanium, a shape-memory alloy that can return to its original shape when heated after surgery. Plus, most of it can be produced using a 3D printer, keeping costs low. Estimates place the robot in operating rooms within the next decade.



DID YOU KNOW?

The first operation performed with the assistance of a robot was in Vancouver in 1983. The robot's name was Anthrobot

A robotic surgeon has been developed that's so agile that it can navigate its way to the brain from a patient's cheek, disturbing much less of the brain

71

Microchips ahoy!

How the insertion of microchips improves neurological conditions

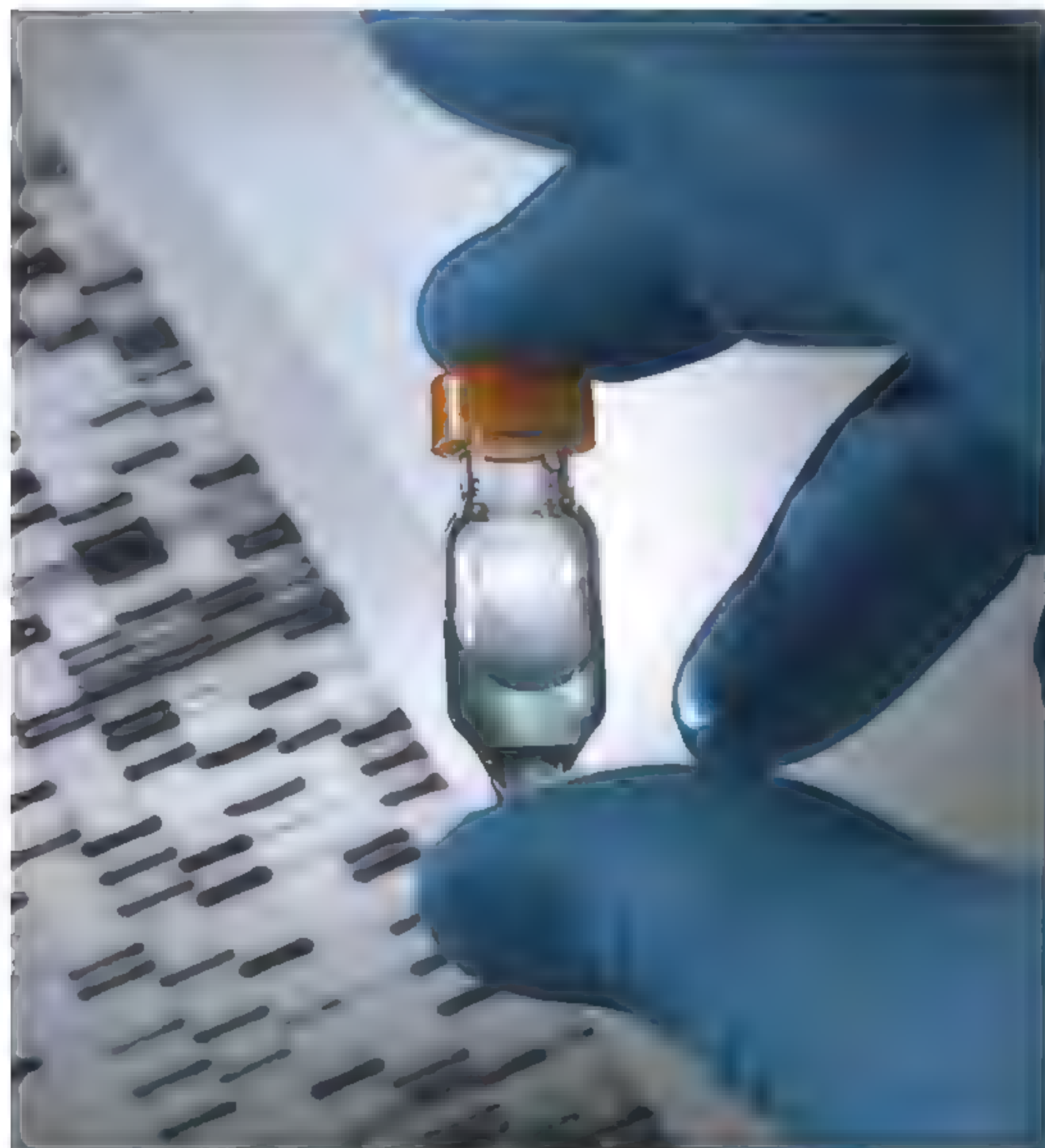
QUADRIPLEGIC IAN BURKHART from Ohio has had a tiny microchip inserted into his brain that's allowed him to move his arm for the first time since being paralysed in a swimming accident at the age of 19. The size of a pea, the chip was implanted into his motor cortex, the brain region that controls movement. The chip interprets his brain signals, sending them to an external computer where they're recoded and sent on to an electrode stimulation sleeve on Burkhardt's arm, which then moves.

The technology, Neurobridge, was developed by researchers at Ohio State University and technology company Battelle Memorial Institute. But it is not alone. Another device is the 'neuro-chip'. Developed at the University of Padua in Italy, it's a 1cm² microchip packed with transistors and capacitors to record and stimulate hundreds of mammalian brain cells. "The dream is to build advanced neuroprostheses where injured or degenerated brain tissue could be replaced or restored by implanted chips," says research leader Professor Stefano Vassanelli.



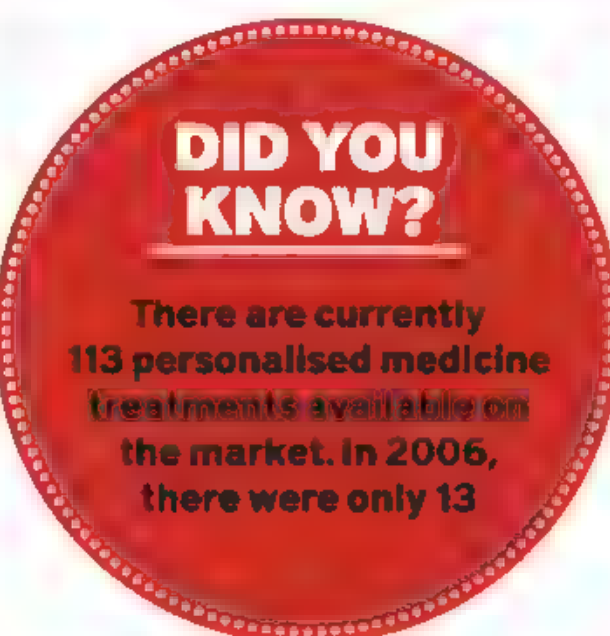
72 Personalised medicine

Medication isn't a one-size-fits-all business



FOR GENERATIONS, WE'VE all taken the same drugs at the same dosage for our various ailments. But our genes have a big influence on the effect that medication has on our body. In personalised medicine, the drugs we are prescribed by doctors would be determined by our genetic code – and we are already seeing the first signs of it.

Tamoxifen was a drug commonly prescribed to women with a particular form of breast cancer, but 65 per cent of women developed a resistance to it. It was found that women with a specific form of the CYP2D6 gene were unable to break down Tamoxifen, making it ineffective. Tests are now carried out before treatment to find women with this form of the gene,



so they can be given alternative treatment.

As well as genes being different, there's also diversity in the genomes of the cancers they carry. Learning more about this will help us to pinpoint the best treatment.

73 Growing organs

Tissue engineering may mean that waiting for a transplant becomes a thing of the past

PATIENTS WITH BADLY diseased or damaged organs often face a gruelling wait for a transplant organ – and many don't make it. But the burgeoning field of tissue engineering may soon



overcome the shortage of suitable transplant organs. In tissue engineering, replacement organs are grown from the patient's own cells, eliminating the need for a matching donor organ.

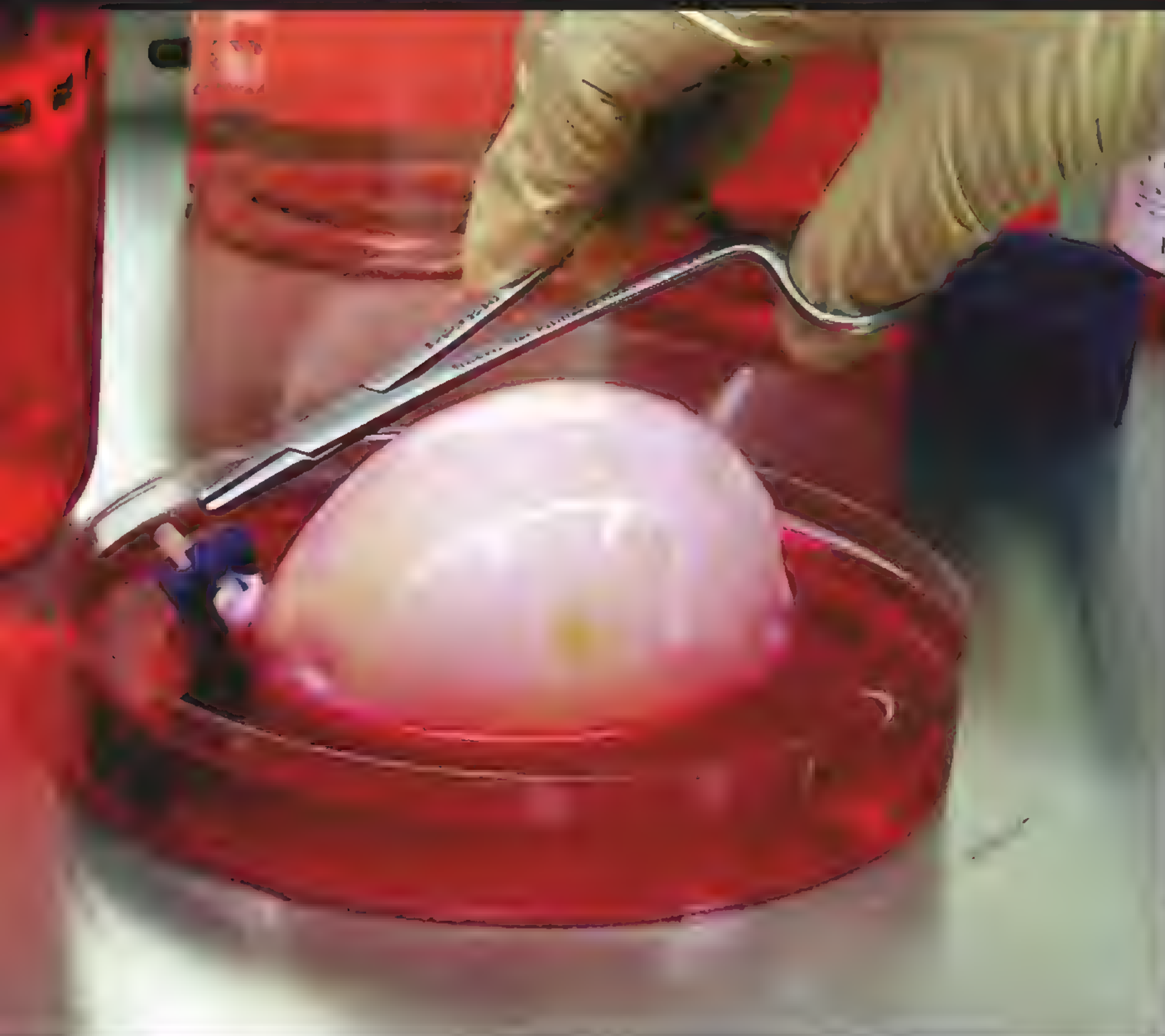
A world leader in the field is Anthony Atala, director of the Institute for Regenerative Medicine at Wake Forest School of Medicine, North Carolina. In 2006, he announced that he had implanted tiny tissue-engineered bladders into a group of 4-19-year-olds, all of whom had a congenital bladder defect. The bladders had grown in

biodegradable moulds, or scaffolds, using muscle cells and cells that line the bladder walls harvested from the patients. The small artificial bladders were then sutured onto the patients' original bladders, supplementing their activity.

Since Atala's announcement nearly a decade ago, progress in tissue engineering has continued apace. In 2011, doctors in Sweden gave a 36-year-old male cancer patient a windpipe grown from his own cells and, in that same year, Atala announced he had successfully implanted artificial urethras into five

boys. Then, two years later, researchers at Yokohama City University in Japan announced they had been formed rudimentary livers from stem cells in mice.

In tissue engineering, replacement organs are grown from the patients' own cells



74 **Bacteria busting**

With bacteria developing resistance to traditional antibiotics, alternatives are needed to prevent unnecessary deaths

BACTERIA THAT are resistant to antibiotics are one of the principal threats to the healthcare system. Left unchecked, the likes of methicillin-resistant *Staphylococcus aureus* – or MRSA as it is better known – could make even routine operations life-threatening. But help may be at hand.

Dutch biotech company Microcos has developed a new treatment that is effective at combating *Staphylococcus aureus*, while leaving potentially beneficial bacteria unharmed. Conventional antibiotics target the inside of a bacterial cell to destroy it, but part of the reason why they are

becoming less effective is that certain strains of bacteria have developed impenetrable membranes.

But Staphetek, an enzyme found in a virus, kills bacteria by destroying their cell walls. It targets specific parts of the membrane that are unlikely to change as the bacteria mutate over time, the theory being that the bacteria should not develop resistance.

Staphetek creams are already available as a treatment for skin conditions in Germany and the Netherlands, and Microcos hopes a pill or injectable version will be available as an MRSA treatment soon.

Certain strains of bacteria have developed membranes that cannot be penetrated by conventional antibiotics

CORBIS / CATRA



DID YOU KNOW?

The iStethoscope app uses a cell phone to record heartbeats, which are then sent to a physician



75 Smartphone diagnostic apps

How everyday technology can detect ongoing conditions

OUR SENSOR-PACKED smartphones are becoming increasingly effective tools for medical diagnosis, with apps used to check for everything from hearing loss to skin cancer.

Massachusetts Institute of Technology has developed CATRA, a system to detect cataracts, the main cause of blindness. A \$2 eyepiece is clipped to a cellphone, fitting over a portion of the screen. When someone looking through the eyepiece sees a faded image on the screen, they press a button. By recording when

the button was pressed, CATRA records the extent of a cataract.

At Dartmouth College in New Hampshire, computer scientists are investigating whether smartphones can also be used to assess mental well-being. In an initial 2014 study, 48 students let the StudentLife app record their movements, the timing of calls and texts, and whether a conversation was taking place nearby. Changes in the patterns were found to correlate with changes in depression, loneliness and stress.

Sensor-packed smartphones are becoming increasingly effective tools for medical diagnosis

76

Face transplants

Microvascular surgery at its most complex

THE FIRST PARTIAL facial transplant was carried out in 2005 on a French woman, Isabelle Dinoire (pictured), who had been mauled by her dog and needed a new nose, chin and lips. Then, in Spain in 2010, a man injured in a shooting accident received the first full-face transplant. Since then, there have been numerous full-facial transplants around the world. The first recipient of a complete donor face in the US was Dallas Wiens, in March 2011. He had been burned in an electrical accident in 2008 and received his donor face at Brigham and Women's Hospital in Massachusetts.

Facial transplants are understandably complex procedures: the first full-face transplant took 22 hours and involved more than 30 doctors. Stitching the face and accompanying blood vessels requires complex microvascular surgery and the recipient must take immunosuppressant drugs for the rest of their lives to make sure that the donated face is not rejected.

Despite the complexity of the procedure, the number of face transplants will continue to grow. In 2009, Brigham was handed \$6.4m by the US Department of Defence to fund 10 face transplants.

77

Gene genie

How gene editing fights inherited conditions

IN GENE EDITING, DNA is inserted, replaced or removed from cells inside a patient's body, either to correct diseases caused by faulty genes, or to offer protection against certain conditions. The first treatments are already here, but many more are on their way.

As viruses bind to cells and introduce genetic material as part of their replication process, they represent an obvious gene therapy tool. Here a new gene is added to the virus's DNA and the gene becomes incorporated into the cell once the virus has gained access to it. The world's first gene therapy drug – a cancer treatment called Gendicine that's currently available in China – uses an adenovirus to deliver genes.



The western world's first gene therapy is Glybera, which helps patients with the rare genetic condition lipoprotein lipase deficiency (LPLD), in which patients' blood becomes clogged with fat. It has been dubbed the world's most expensive treatment, reportedly

costing \$1.4 million per patient. At present, it is licensed for use in Europe but not the US.

With a host of other treatments being tested, including those that confer protection against HIV and leukaemia, gene therapy is a treatment that is coming of age.

78

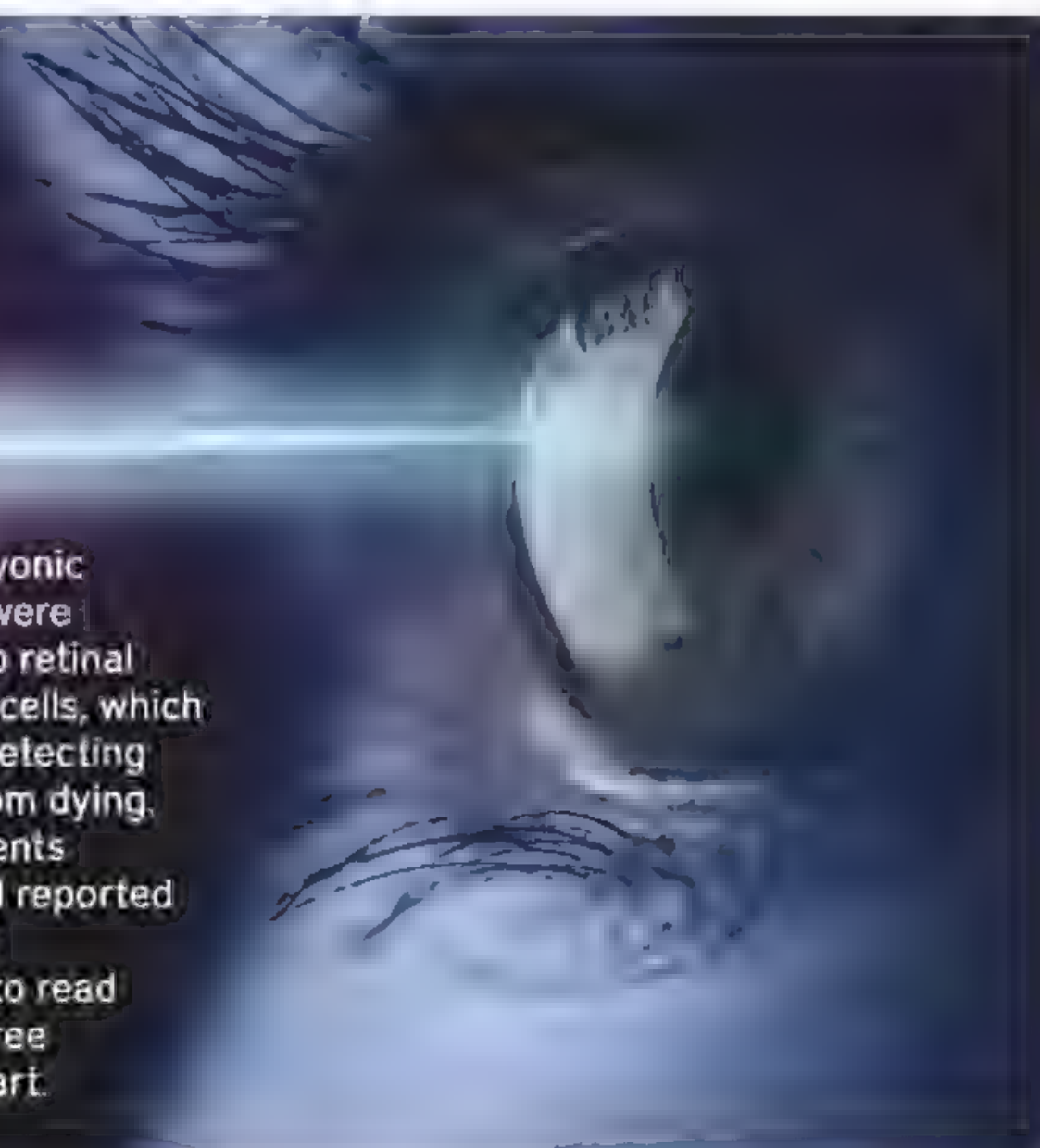
In their sights

Stem cells can reverse degenerative vision

MACULAR DEGENERATION IS one of the leading causes of blindness worldwide. The condition, though, could be reversed by injecting stem cells into the eye.

Massachusetts biotech company Advanced Cell Technology and eye specialists at the Jules Stein Eye Institute in Los Angeles carried out a three-year study into whether the procedure was safe, and found that some patients experienced visual improvement.

The technique started with embryonic stem cells. These were coaxed to turn into retinal pigment epithelial cells, which prevent the light-detecting photoreceptors from dying. Half of the 18 patients injected in the trial reported that their eyesight improved enough to read an extra two to three lines on an eye chart.



79 Bionic vision

The eye-opening benefits of new optical technology

IT TOOK TWO decades of research and development, but the first bionic eye, the Argus II, went on sale in 2011 in Europe and 2013 in the US. Developed by California-

based company Second Sight, it's blazed a trail for what is likely to be a burgeoning field in future years.

The Argus II consists of a camera, mounted on a pair of glasses, that captures images before relaying signals wirelessly to a chip implanted near the retina. An array of electrodes in the chip stimulate retinal cells, producing light in the patient's field of view and providing limited vision. The technology is an effective treatment for patients with retinitis pigmentosa, which damages the light-sensing photoreceptors.

Other technology, such as Bionic Vision Australia's High-Acuity Device, also uses an external camera and a microchip implant in the eye. But the Artificial Silicon Retina - developed by brothers Dr Alan Chow, an assistant professor of ophthalmology at Rush University Medical College in Chicago, and electrical engineer Vincent Chow - detects light from within the eye and requires no externally worn devices. Initial trials in volunteers have proved successful.



80 Early seizure detection

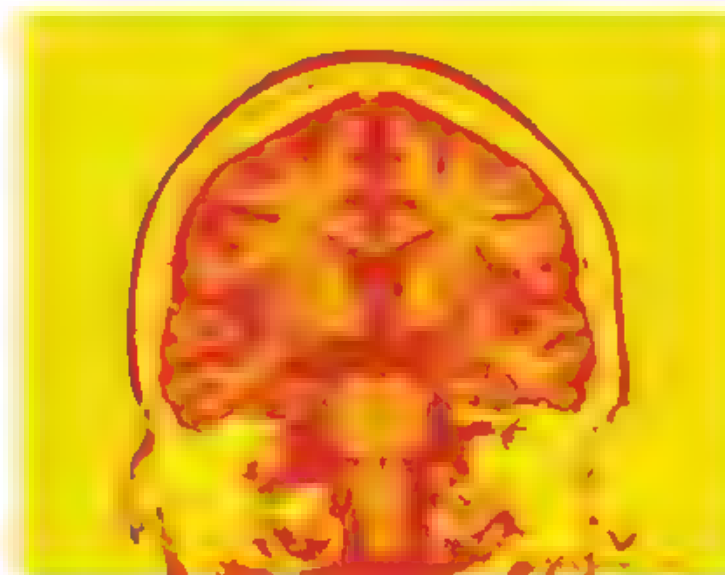
Medication doesn't work for nearly a third of epilepsy sufferers. Help, though, is at hand...

FOR MANY PEOPLE with epilepsy, drugs are able to prevent seizures from occurring. For some, though - around 30 per cent of sufferers - drugs are ineffective. But now a new treatment is available to epileptics who don't respond to medication. It involves electrical stimulation of the brain regions that are the source of the seizures.

The RNS System, from Neuropace in Mountain View, California, consists of an electrical implant placed in the brain at the seizure hotspots. When it detects abnormal pre-seizure brain activity, it stimulates these brain regions, interrupting the activity and averting a seizure.

The RNS System is an alternative to the vagus nerve stimulator (VNS)

that's been fitted to tens of thousands of patients since the late 1990s. The VNS is connected to the vagus nerve in the neck, sending regular, mild electrical stimulations to it, calming the irregular brain activity that leads to seizures.



81

Robot nurses

Ingenious solutions to the looming crisis of a population getting older

WITH THE HIGHEST life expectancy in the world – coupled with one of the lowest birth rates – there are too few people in Japan to look after its ageing population. So an ingenious technological fix is being developed for the problem, in the shape of robot nurses that can either help patients directly or aid those hard-pressed nurses in their duties.

Leading the march is the Hybrid Assistive Limb (HAL for short), a powered exoskeleton suit developed by Tsukuba University and robotics company Cyberdyne. HAL is battery-powered and detects nerve impulses to muscles in order to anticipate and support the user's movements. The rigid frame provides support while the motors move the limbs. Exoskeletons like HAL could also be used by nurses to help them carry patients.

Toyota is developing a range of 'partner robots' to help rehabilitate patients. Like HAL, its Walk Training Assist Robots can be attached to a paralysed leg to help the user re-learn how to walk and stand, while the Balance Training Assist Robot helps patients regain control of their balance by encouraging them to control characters in video games with their bodies. Toyota plans to make both robots commercially available.

DID YOU KNOW?

It is estimated that the exoskeleton market will be worth \$45bn by the year 2020



82 New ways to remove bad cholesterol

Reducing a main cause of serious cardiovascular disease



There are just four people in the world who have been identified with a mutation that means they don't produce the enzyme PCSK9

'BAD' LOW-DENSITY lipoprotein cholesterol (LDL-C) is one of the biggest causes of cardiovascular disease, and is currently kept in check using statins. But in some people, statins fail to reduce LDL-C to recommended levels. Controlling levels of an enzyme PCSK9 in the body could well be the solution – and a group of people with a rare genetic mutation shows us why.

There are just four people in the world who have been identified with a mutation that means they don't produce PCSK9 – and all have very low cholesterol levels. PCSK9 destroys receptors on the surface of the liver

that bad cholesterol attaches to so that it can be drawn out of the bloodstream. Not producing PCSK9 means that more cholesterol receptors on the liver stay intact, so more cholesterol is removed from the blood.

Several drugs companies, including Pfizer, are now carrying out clinical trials on monoclonal antibodies – proteins found in the immune system – that destroy PCSK9. Consistently, LDL-C levels have dropped thanks to these PCSK9-destroying proteins; one trial even saw a fall of over 60 per cent over the course of 10-12 weeks.

83

The cancer blocker

The development of the drug ibrutinib could mean the end of chemotherapy for leukaemia sufferers

A NEW DRUG that has proven effective in treating the most common form of leukaemia could spell the end of traditional chemotherapy for that form of cancer. In an international trial, ibrutinib gave patients with chronic lymphocytic leukaemia (CLL) a 90 per cent chance of survival, compared to 81 per cent with conventional treatment.

In CLL, the body produces abnormal white blood cells, or lymphocytes; specifically, a type of lymphocyte called a B cell. As the disease progresses, these cells grow out of control, crowding out the healthy cells in the blood, bone

marrow, liver, spleen and lymph nodes. Ibrutinib works by disabling an enzyme called Bruton's tyrosine kinase, which usually allows the cancer cells to grow and divide. It is even effective at treating both patients whose leukaemia has returned, and those who have not responded to other treatments. As it is a targeted therapy, ibrutinib kills cancer cells without killing healthy ones.

Ibrutinib is approved by the FDA for treatment of CLL, as well as mantle cell lymphoma. It is now also being investigated as a treatment for other B-cell cancers, such as multiple myeloma.





84 **The vaccine patch**

VAXXAS / CORBIS

The cheap and highly effective alternative to the syringe

PLACING A TINY patch onto the skin could soon be a pain- and phobia-free way to receive a vaccine. The Nanopatch, developed by Professor Mark Kendall at the University of Queensland, Australia, is just 1cm² and has proven itself to be more effective than traditional needles and syringes.

The patch is covered in invisible 'microprojections'. When it's placed on the arm, these projections pierce the skin, releasing the vaccine they are coated in. As the area beneath the skin is rich in immune cells, the patch is highly effective at initiating an immune response – vital for preparing the body to quickly fight off infections.

85 Talking the talk

The use of voice recognition software may enable crucial early diagnosis of Parkinson's disease

SPEECH RECOGNITION technology may allow Parkinson's disease to be diagnosed by simply using a recording of someone saying 'ahhh'. Early tests of the technology have shown it to be 99 per cent accurate.

Parkinson's is the second most common neurodegenerative disease after Alzheimer's disease, affecting one million people in the US alone. Yet it's difficult to diagnose: no lab tests are available, so diagnosis relies on in-clinic assessments of muscle strength, reflexes and other characteristics, as well as brain scans. There are currently no cures for Parkinson's, but early diagnosis means drugs can

be prescribed that will delay the condition's progression.

In the test developed by Dr Max Little, chairman of the Parkinson's Voice Initiative, a recording of the patient's voice is analysed using voice processing tools, and compared to a database of recordings of Parkinson's and non-Parkinson's patients. Those with Parkinson's show certain vocal symptoms, such as tremors. As well as initial diagnosis, the system can be used to monitor the progression of the disease.

The project is currently collecting 10,000 telephone-quality recordings to test how accurate the software is at detecting Parkinson's.

The Nanopatch uses as little as 1 per cent of a traditional vaccine dose

So effective is the Nanopatch that it provides immunity with as little as 1 per cent of the traditional vaccine dose, greatly reducing the cost of vaccination. It can also be stored at room temperature. Field tests have been taking place in Papua New Guinea, where it is being used to vaccinate against human papilloma virus, which causes cervical cancer.



86 3D printed organs

Extraordinary artificial kidneys and livers

EACH DAY, 12 people die in the US waiting for a kidney transplant. But at Harvard University, a solution is under way: kidneys built in 3D printers that use cells and the materials that connect them as their 'ink'.

Researchers have printed rudimentary versions of nephrons, the basic unit of the kidney that filters the blood. They have also started to overcome one of the biggest challenges in printing

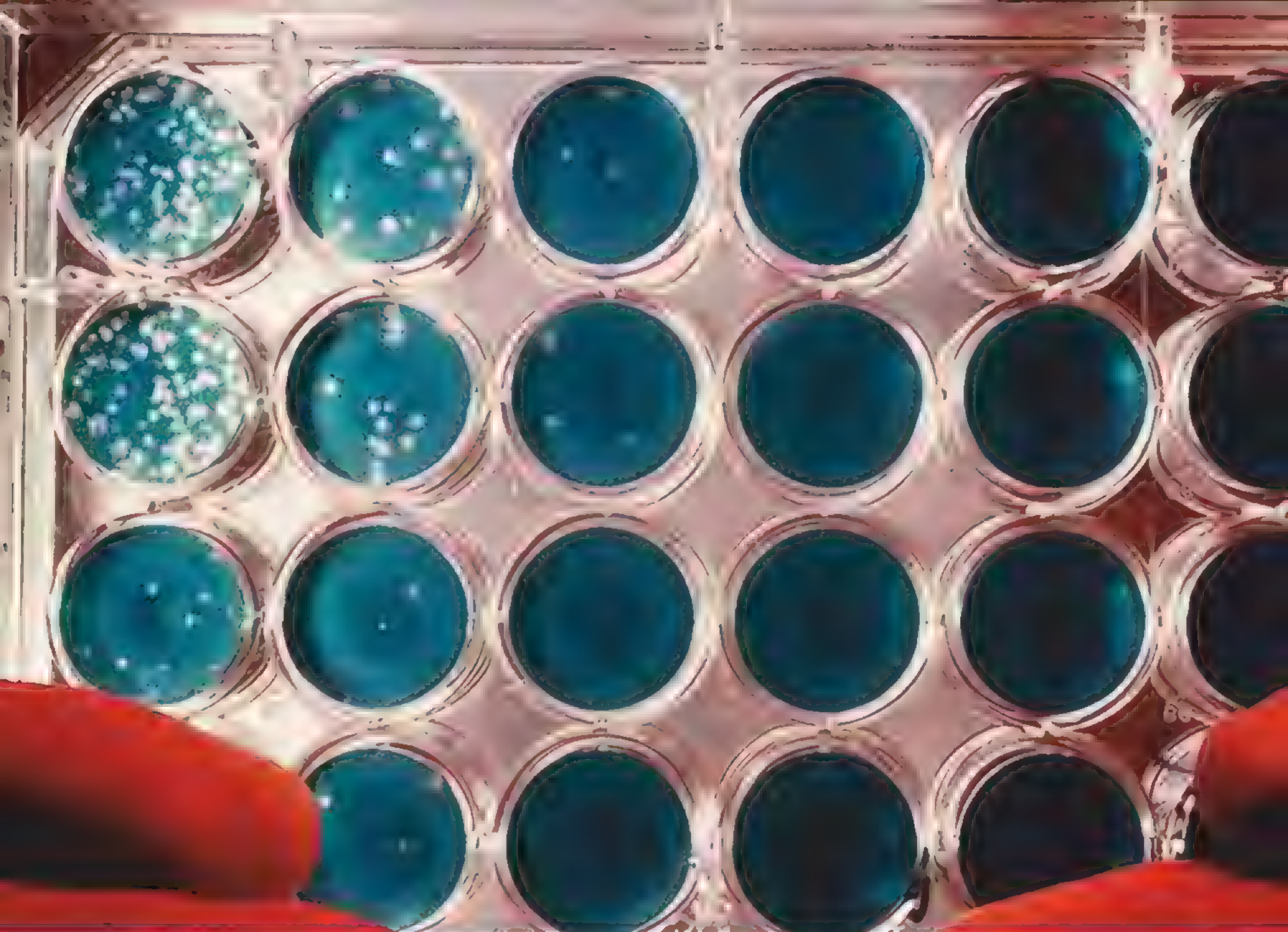
DID YOU KNOW?

Although 3D printing technology is advancing rapidly, it currently takes around 10 days to print an average-sized liver

complex organs – building blood vessels that keep the tissue alive – by making tunnels inside the tissues lined with blood vessel cells.

At Massachusetts Institute of Technology, researchers have printed what they call 'contact lens livers' – rudimentary livers for mice consisting of about one million cells and resembling a contact lens. Now they must scale the livers up to human size – about 100 billion cells.





87 **New hepatitis C treatments**

Medication to tackle the blood infection has traditionally provoked extensive side effects. Until now...

HEPATITIS C is usually spread when the blood from an infected person enters the body of someone else. As such, there are many ways to become infected, including sharing needles used to inject drugs or being born to a mother with hepatitis C. The NHS estimates that around 215,000 Britons are infected

with hepatitis C – and many don't know they have the virus until they have some liver damage.

Treatment is hard work. The drugs commonly used to combat the condition, interferons and ribavirin, are associated with extensive side effects, including flu-like symptoms and fatigue.

In one trial, the drug Harvoni – a combination of two existing hepatitis C-fighting drugs – cured 97.7 per cent of patients within 12 weeks

In fact, many people simply give up on the treatment. However, a new drug gives patients fewer side effects, as well as being more effective.

The drug, Harvoni, is a combination of two hepatitis C-fighting drugs, ledipasvir and sofosbuvir. Both work by interfering with the enzymes needed by the virus to multiply. In one trial by Californian biotech company Gilead Sciences, the pill cured a highly impressive 97.7 per cent of patients within 12 weeks. In some cases, a combination of interferon and ribavirin has only had a success rate of 50 per cent.



88 Music to their ears

Cochlear implant gene therapy may allow wearers to hear music

COCHLEAR IMPLANTS HAVE been around since the 1970s, and have restored hearing in more than 300,000 people worldwide. But while recipients of implants can typically hear speech, they have trouble distinguishing pitch, so they are unable to appreciate music. That may be about to change.

The lack of pitch definition is due to the nerve cells conveying

information about sound from the cochlea to the brain. When the cochlea stops functioning properly, these nerves start to wither away, losing their ability to convey pitch. But researchers at the University of New South Wales in Australia have reversed this deterioration.

Firstly, the area of the ear where the cochlear implant will be fitted is infused with DNA that encodes for

the production of a protein called brain-derived neurotrophic factor (BDNF). When the cochlear implant is inserted and starts producing brief electric bursts, it disrupts the membranes of nearby cells, so the DNA can enter. The cells then produce BDNF, causing the nerve cells to regrow, restoring pitch definition. A clinical trial of the technique is planned.

The lack of pitch definition is due to the deterioration of nerve cells that convey information about sound to the brain

89 **Miniature heart pumps**

Fitting such a device can buy time for heart failure patients

WHEN CHRONIC HEART failure leaves patients bedridden and breathless, and a heart transplant is not available, a mechanical heart pump, or 'ventricular assist device' (VAD), can buy them time – and a relatively normal life. Once the size and shape of a flattened grapefruit, VADs sat outside a patient's chest and were linked to a control unit the size of a refrigerator. But miniaturisation is working miracles, and the HVAD from HeartWare is a prime example. The size of a golf ball, it is fitted inside the patient's chest and its

control unit is so small that it fits on a belt or in a handbag.

Since 2006 the HVAD has been fitted to 7,000 patients who've suffered heart failure, and there is huge potential demand for this technology. In the US, there are about 2,500 heart transplants each year; in the same period, 500,000 new patients are diagnosed with heart failure.

HVAD is able to pump seven or eight litres of blood per minute around the patient's body, allowing patients to leave hospital, return to work or school, go for a walk and generally get back to living their

lives. Ideally, the HVAD acts as a 'bridge' to a heart transplant – and its impact is huge. Less than half of patients receiving medical therapy for heart failure survive for one year, whereas 86 per cent of patients with HVAD survive the year. Many live even longer, and one had the HVAD for a full seven years.

While HVAD is diminutive, HeartWare has developed another, even smaller VAD called the MVAD, which is less than half the size. Clinical trials are expected in the US, Australia and Europe during 2015.



90 Deleting traumatic memories

Introducing the drug that reduces the effects of bad experiences

OUR GROWING KNOWLEDGE of how the brain works is allowing us to think what would have been unthinkable even a decade ago: we may soon be able to erase traumatic memories from our minds, or at least dampen the negative emotions they evoke.

In one study at Massachusetts Institute of Technology, when mice were given a drug known as a histone deacetylase inhibitor (HDAC), it was easier to eliminate the negative reaction they showed to a loud sound that had previously coincided with an electric shock to

the feet. Painful memories are thought to be hard to erase because they make changes in the chemical marks that surround our DNA, the epigenome. But HDACs are thought to clear epigenetic markings from DNA which, in the case of the mice, meant that the negative associations could more easily be eliminated. But much research is needed before HDACs could be considered as a treatment for painful memories in humans, including determining how specific the modifications are to memory.



DID YOU KNOW?

Genetic disorders – conditions caused by an abnormality in the human genome – affect approximately 6 per cent of the global population

91 Snap decision

How the revolutionary use of photographs gives doctors an objective – and early – diagnosis of genetic conditions

It is thought that 30-40 per cent of rare genetic disorders involve some kind of facial change

DOCTORS WILL SOON be able to analyse family photos to help them diagnose rare genetic disorders in children. New computer software, developed at the University of Oxford, is able to identify subtle facial characteristics and recognise conditions such as Down's syndrome and Angelman syndrome.

It's thought 30-40 per cent of rare genetic disorders involve some kind of facial change, possibly because so many genes are involved with the development of the face in the womb. Currently largely reliant on their own judgment, doctors will use the software to narrow diagnoses.

The system has been fed photos of children with genetic conditions and those without. When presented with the face of a child for diagnosis, the software identifies features like the corners of the eyes and mouth and compares them against what it has learned from the other photos.

"A doctor should in future be able to take a smartphone picture of a patient anywhere in the world and run the analysis to quickly find out which genetic disorder the person might have," says Dr Christoffer Nellåker at Oxford, who helped to develop the technology.



92

Breath tests for lung cancer

Detecting the major killer using the simplest of devices

LUNG CANCER IS one of the most common forms of cancer in the UK, with some 41,000 new cases diagnosed each year. But soon doctors will have a new diagnostic tool – an electronic nose that's so

simple it could be used for widespread screening.

One new detection system (several are in development around the world) named NaNose is a joint project involving the University of



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Colorado Cancer Center and Technion University in Haifa, Israel. It requires a patient to blow up a balloon which is then attached to a sensor containing gold nanoparticles. The nanoparticles trap and then

help to analyse volatile organic compounds in the exhaled breath.

"The metabolism of lung cancer patients is different from the metabolism of healthy people," explains Fred R Hirsch

at the University of Colorado. The differences in metabolism produce differences in the volatile organic compounds that can be detected in the breath. The device is currently in development.



93 Hypothermia surgery

Replacing a patient's blood with chilled saltwater

IF OUR CORE body temperature drops below 22°C (72°F), it is usually fatal. But some surgeons are cooling their patients' bodies to 18°C (64.4°F) and below – and it is saving their lives.

Therapeutic hypothermia involves replacing all the patient's blood with cooled saltwater, stopping most activity in their cells. Without heart and brain activity, they are clinically dead. Usually, the brain can only survive without oxygen for about

five minutes before damage to it is irreversible. But at lower temperatures, the cells need less oxygen as all the chemical reactions go into slow motion. Once surgery is complete and the patient warmed up, their heart is restarted with a defibrillator.

The technique is used in surgery at Yale-New Haven Hospital, Connecticut, when the heart needs to be stopped to carry out a procedure and a heart-lung bypass is not feasible.

At lower temperatures, human cells require less oxygen than usual as all the chemical reactions go into slow motion



94 Stem cell treatment for Parkinson's

The latest research into creating dopamine-producing cells

NEW BRAIN CELLS may one day be transplanted into sufferers of Parkinson's disease to reverse the effects of the neurological condition. While there are currently medications to treat the symptoms, none reverse its progression. But Swedish researchers have discovered a potential way to patch up a brain damaged by the neurodegenerative disease.


About one million Americans have been diagnosed with Parkinson's, the symptoms of which include trembling and speech changes. These symptoms are caused at least in part by the loss of dopamine-producing cells. Researchers at Lund University in southern Sweden took human embryonic stem cells and

transformed them into motor neurons. The neurons were transferred into the brains of rats with Parkinson's-like symptoms. The implanted cells connected to existing cells in the rat brain and started producing dopamine.

The Swedish researchers' next step is to produce the cells in a way that would mean they could be transplanted into humans. If all goes well, clinical trials could start in around three years' time.

DID YOU KNOW?

Parkinson's is named after the pioneering 19th-Century English doctor James Parkinson



Each year, 50,000 Americans
and 2.3 million people worldwide
become infected with the HIV virus

95

Protect and survive

The ongoing battle to produce an effective HIV vaccine

FOR MORE THAN two decades, scientists around the world have been working to develop a vaccine for HIV. Around 110,000 people in the UK and 35 million people worldwide are living with the virus, but real progress is now being made towards a vaccine that is at least partially effective.

The most successful trial to date, carried out by the US Military HIV Research Program, involved 16,000

adults in Thailand who were given two vaccines – one as a prime and another as a boost. This proved to be 31 per cent effective at preventing HIV infection. This research is continuing, with a modified version of the vaccine, plus a further booster, being trialled in South Africa in 2015.

Another vaccine at an advanced stage has been developed at the University of Western Ontario in

Canada. It is unusual in that it involves a genetically modified version of the whole HIV virus – many vaccines involve just part of the virus. An early clinical trial on people already infected with HIV has shown it to be safe as well as boosting antibody production. Additional trials by the university and biotech company Sumagen will investigate this immune response further.

96

Cancer immunotherapy

After decades of painstaking research, the immune system is now being used in the fight against cancer

THE IDEA SOUNDS simple – use a patient's immune system to fight off cancer. Only now though, 60 years after research started, are the endeavours of scientists paying off.

A leader in this rapidly developing field is James Allison from the MD Anderson Cancer Center in Houston, Texas. He has developed the 'checkpoint blockade' approach to cancer therapy. Here, antibodies target specific molecules on immune cells that empower them to hunt down and attack cancer cells. The first antibody drug to do this was ipilimumab, approved by

the Food and Drug Administration in 2011 as a treatment for patients with metastatic melanoma, a cancer largely resistant to standard chemotherapy. A dozen antibodies are now approved as cancer treatments.

Another technique involves removing immune cells from the body, re-engineering them so they attack cancer, and then placing them back in the body. Yet another involves cytokines – proteins that regulate the immune system, which can be used to enhance the immune system's tumour-fighting abilities.

97 The development of artificial skin

Grown in the laboratory, the advent of artificial human skin could bring an end to controversial animal testing

LAYERS OF ARTIFICIAL human skin grown in the lab could soon replace animals in drug and cosmetics testing. The skin is grown from stem cells and is a close match for the real thing.

Tissue engineers have been able to grow artificial epidermis, the outermost layer of skin, for some time. So far, though, it has failed to sufficiently replicate real skin's properties as a barrier to enable it to be used in drug and cosmetics testing. But, in 2014, an international team of researchers, led by San Francisco Veteran Affairs Medical Center (SFVAMC) and King's College London, announced they had developed

artificial epidermis that acts just like our natural barrier.

They grew epidermal cells from induced pluripotent stem cells – highly adaptable stem cells created from specialised, adult cells. The properties of the artificial skin mimic the skin of the donor of the original cells, so there is another opportunity too. "The ability to obtain an unlimited number of genetically identical units can be used to study a range of conditions where the skin's barrier is defective, such as ichthyosis [dry, flaky skin] or atopic dermatitis," says Dr Theodora Mauro, leader of the SFVAMC team.



The skin is grown from stem cells and is a close match for the real thing

98 Pressure drop

How a blood pressure drug could reverse the effects of diabetes



A DRUG THAT treats high blood pressure and migraines may soon be used to treat another condition: diabetes. In tests, verapamil completely reversed type 1 diabetes in mice and the hope is that it will do the same in humans.

Type 1 diabetes is the less common form of the disease, only accounting for five per cent of cases. But it's a serious condition for those who have it. It progresses in a self-fulfilling cycle: the pancreas starts producing less insulin and sugar levels in the body rise, increasing levels of a protein called TXNIP, which kills the insulin-producing beta cells in

DID YOU KNOW?

Around 10 per cent of all diabetes is type 1, where the pancreas doesn't produce **any** insulin, as opposed to type 2, where the pancreas doesn't produce **enough**

the pancreas. This means that even less insulin is produced, sugar levels rise further and so more TXNIP is produced. But researchers at the University of Alabama, Birmingham, have found that verapamil stops TXNIP killing beta cells, halting the cycle in its tracks and allowing insulin production to ramp up again.

A clinical trial this year will see how effective the drug is at treating diabetes in humans.

99 Infertility investigations

Removing a woman's ovaries may actually aid conception



RESEARCHERS HAVE FOUND a way to induce the ovaries of some infertile women to produce eggs. Although first being tested on women with a condition called primary ovarian insufficiency, it's hoped the treatment could help other women with fertility problems too.

Primary ovarian insufficiency affects one per cent of women of reproductive age in the US. They

enter menopause before the age of 40, leaving egg donation their only option for having a baby.

The technique, developed by researchers in Japan and at Stanford School of Medicine, was initially used to treat Japanese women. This early trial has already led to two births, while more couples have frozen embryos yet to be transferred. Treatments have since been given

to women in the US and China, but have yet to yield a pregnancy.

The women had their ovaries removed, dissected and treated with a substance that blocks a protein called PTEN. Small pieces of ovary were then placed near the fallopian tubes of the women. The research is continuing, including investigations into which women respond best to treatment.

100 **Remote control**

When it comes to the operating theatre, a robot's four arms are better than the surgeon's two

OVER 1.5 MILLION surgical procedures have been carried out by the world's leading surgical robot, the da Vinci Surgical System, since it was first used in 2000. With new procedures using the robot being developed all the time, its use is likely to continue to grow.

With da Vinci, the surgeon sits at a console from where he or she can control the robot's four arms – three that hold surgical instruments and one that holds cameras giving a 3D view of the operation. The da Vinci robot converts the surgeon's hand movements into smaller, more

precise movements of the tiny instruments inside the patient's body. This takes the surgery "beyond the limits of the human hand," as da Vinci's manufacturer, Intuitive Surgical, describes it.

The system is commonly used for prostate removal, as well as cardiac valve repairs and gynaecological surgical procedures. But its uses are expanding: in 2014, surgeons at the University of California, Los Angeles, released details of a new surgical procedure involving da Vinci in which a previously untreatable head and neck cancer was removed.

The robot converts the surgeon's hand movements into smaller, more precise movements of the tiny instruments inside the patient's body



THE PIONEER



Charles Richard Drew

Born: 3 June, 1904, Washington DC

Died: 1 April, 1950, Burlington, North Carolina

Known for:

**The development
of blood transfusion**

HAVING USED HIS athletic ability to gain a scholarship at Amherst College, Charles Drew studied medicine at McGill University in Montreal. As an Afro-American, his career choices were limited, but he obtained posts in

pathology and surgery at Howard University Medical School. While at McGill, Drew had acquired what would become a lifelong interest in blood transfusion – a vital medical and surgical procedure after trauma and during major surgery.

With the outbreak of World War II, Drew moved to New York City to work on blood-banking services designed to meet wartime needs. He had already shown that separating the red blood cells from the plasma allowed the latter to be stored and shipped long distances, including to the UK during the early days of the war.

He became medical director of the American Red Cross Blood Bank programme in 1941, organising a massive collection drive. However, the Red Cross accepted a military directive – with no scientific grounding – that blood be sorted on racial lines, leading to Drew's indignant resignation. He returned to Howard University, where his surgical career was prematurely ended by a car accident.

Separated from plasma, red blood cells could be shipped long distances

Joseph Edward Murray

Born: 1 April, 1919, Milford, Massachusetts

Died: 26 November, 2012, Boston, Massachusetts

Known for:

Transplantation surgery

A SPORTSMAN IN his youth, Murray had to give up baseball because practice conflicted with lab work in chemistry. He finished medical school at Harvard during World War II and became fascinated with plastic surgery through his surgical military years, caring for soldiers with burns and disfiguring wounds. He noticed that skin grafts taken from relatives were less likely to be rejected than those from unrelated donors.

After discharge from the army, Murray continued training in plastic surgery, joining the staff of the Harvard-affiliated Peter Bent Brigham Hospital in 1951. Skin grafts had alerted him to the possibilities of transplanting failed internal organs – the skin is an organ as well. In 1954, he transplanted a healthy kidney into Richard Herrick, who was suffering from end-stage kidney failure. Thanks to that kidney donated by his twin brother, he survived for eight years.

The development of drugs that suppressed the natural tendency of the body to reject foreign tissue made donor selection easier, and transplant surgery involving kidneys, livers, hearts and combined heart and lungs began to be done more routinely. The usual pattern was for high post-operative mortality rates in new operations to come down gradually, as follow-up care became more comprehensive. The first human heart transplant, performed in 1967 in South Africa by Christiaan Barnard, was an international sensation, although his patient survived only 18 days.



ERS

THESE FOUR BOUNDARY-BUSTING
SCIENTISTS SIGNIFICANTLY
ADVANCED MEDICAL PRACTICE



Robert Edwards

Born: 27 September, 1925, Batley, Yorkshire, UK

Died: 10 April, 2013, Cambridge, UK

Known for:

**The development of
in vitro fertilisation**

ON JULY 25, 1978, Louise Brown was born. Although conceived in a Petri dish, the media referred to her as a 'test-tube baby'. She was the first child to have been fertilised outside the body and then placed in her

mother's uterus to develop until birth. The result of basic research on reproduction in animals and humans going back decades, Brown's facilitators were the obstetrician/gynaecologist Patrick Steptoe and the reproductive physiologist Robert Edwards. Their research was so controversial that funding was difficult to obtain.

In vitro fertilisation (IVF) had been achieved for rabbits and other laboratory animals, and research on the hormonal regulation of human pregnancy by the Americans Gregory Pincus, John Rock and others provided the foundations for Steptoe and Edwards. Crucial, too, was Steptoe's pioneering use of the laparoscope to visualise the ovaries and harvest eggs. Steptoe and Edwards had to respond along the way to the many legal and ethical issues that IVF raised. Those issues haven't entirely disappeared, but around five million people worldwide have been born as a result of IVF. Edwards won the 2010 Nobel Prize for Medicine or Physiology.

Edwards had to respond to the many legal and ethical issues that IVF raised

John Edward Sulston

Born: 27 March, 1942, Cambridge, UK

Known for:

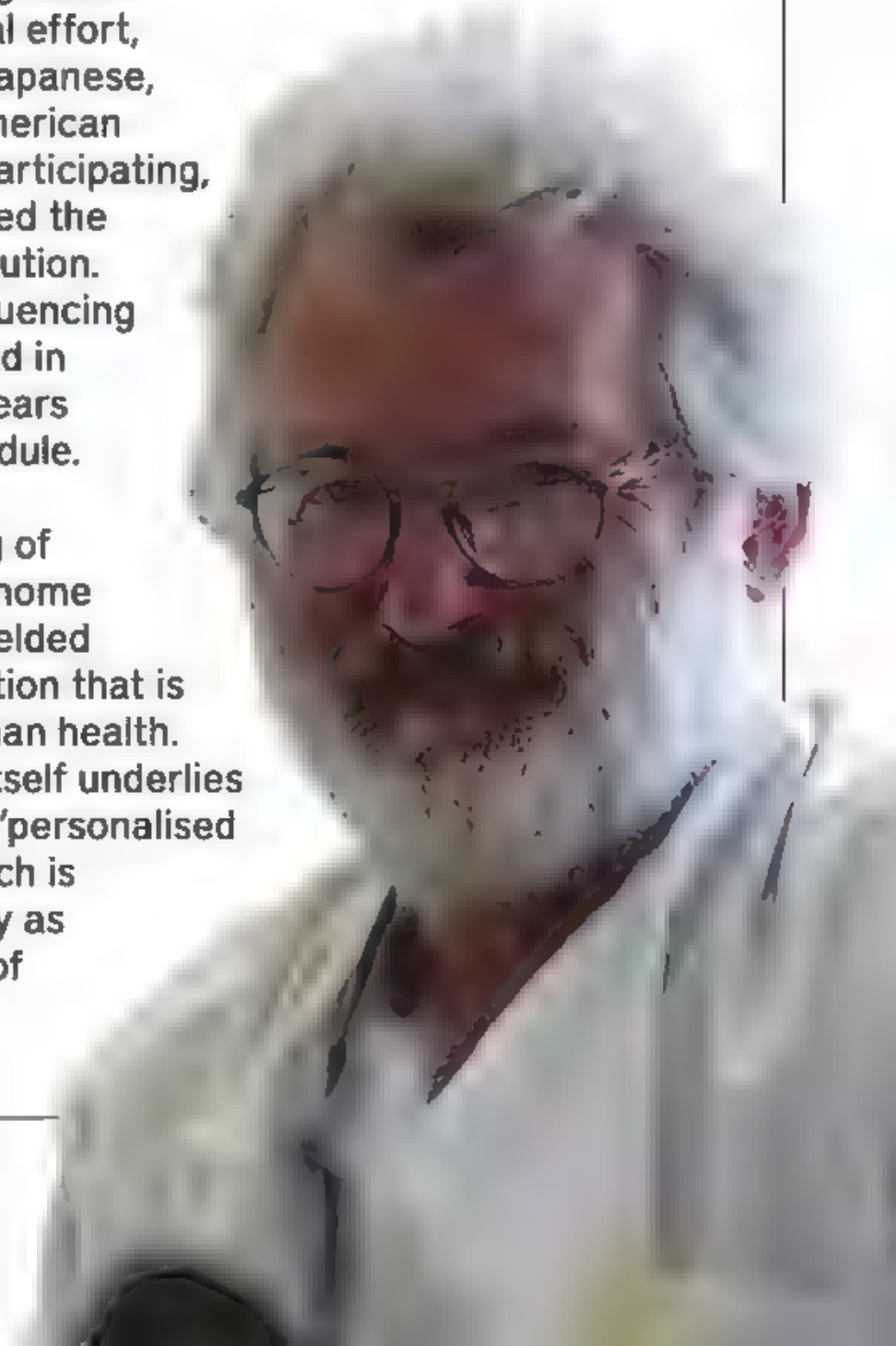
**Sequencing the genome of
C. elegans and human beings**

LIKE MANY OTHER gifted scientists, Sulston turned to molecular biology after James Watson and Francis Crick elucidated the molecular structure of DNA. He studied biochemistry at the University of Cambridge, but soon joined the Laboratory of Molecular Biology at Cambridge, where he, Sidney Brenner and others exploited a tiny roundworm, *C. elegans*, in a systematic study of its genome (the first multicellular organism to have its genome sequenced), cellular functions and development. They made especially important discoveries about programmed cell death ('apoptosis'), a fundamental aspect of cells in all living organisms, and shared (with their American colleague Robert Horvitz) the 2002 Nobel Prize for this work.

By that time, Sulston was heavily involved in a more ambitious project: the sequencing of the human genome.

A multinational effort, with French, Japanese, British and American laboratories participating, Sulston directed the British contribution. The initial sequencing was announced in 2000, three years ahead of schedule.

This new understanding of the human genome has already yielded much information that is useful for human health. The genome itself underlies what is called 'personalised medicine', which is hailed by many as the medicine of the future.



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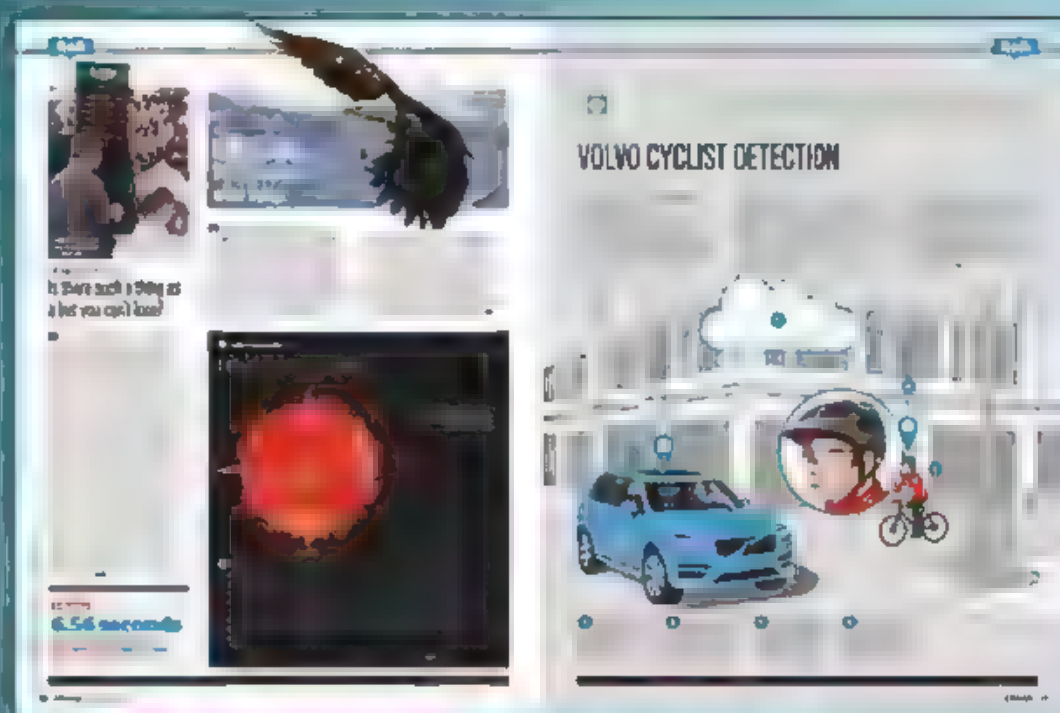
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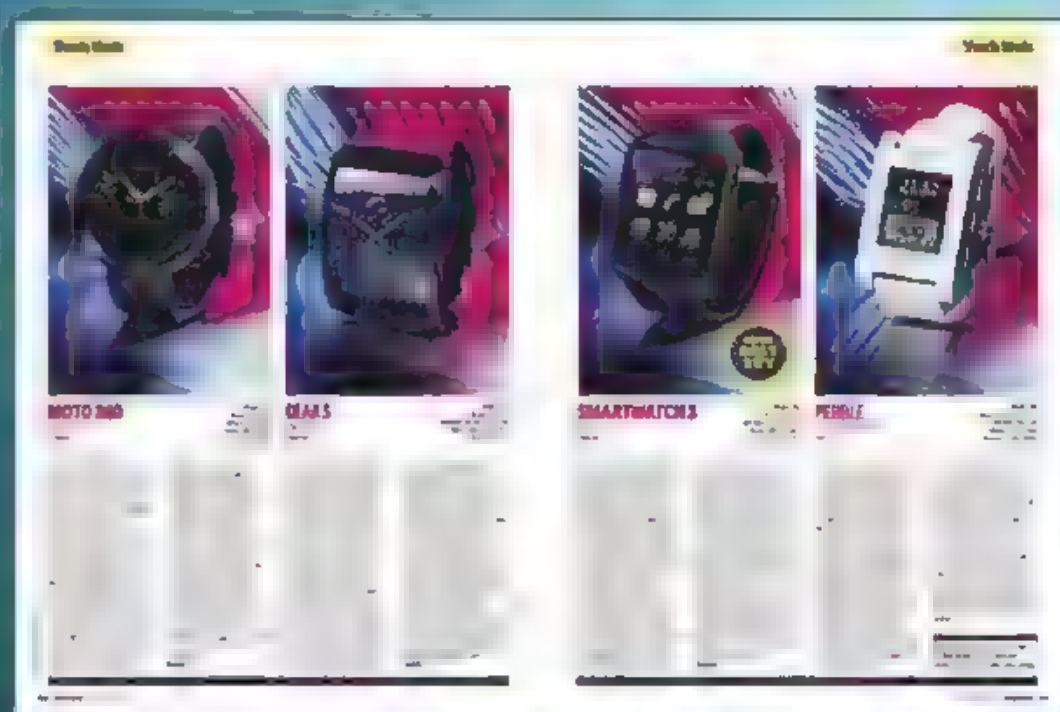
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OF UK CHILDREN'S TOTAL ENERGY INTAKE IS FROM SUGAR (P24)




DRUGS & VACCINES




235,000,000
THE NUMBER OF ASTHMA SUFFERERS ACROSS THE WORLD (P37)

THE LIST OF FAMOUS PERSONALITIES WHO SUFFERED FROM DIABETES INCLUDES ELVIS PRESLEY, ERNEST HEMINGWAY, ELLA FITZGERALD, JOHNNY CASH AND TENNIS CHAMPION ARTHUR ASHE (P37)

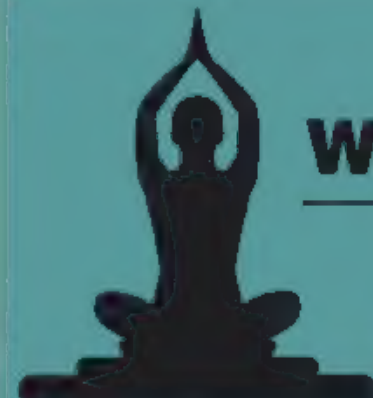


THE NUMBER OF YEARS THAT PEOPLE HAVE BEEN TAKING SALICYCLIC ACID, THE ACTIVE INGREDIENT IN ASPIRIN (P36)

4,000




MIND & WELL-BEING




400 BC
WHEN THE WORD 'YOGA' FIRST APPEARED - IN A HINDU TEXT CALLED KATHA UPANISHAD (P64)

10% THE PROPORTION OF BRITONS WHO WILL SUFFER FROM DEPRESSION AT SOME POINT IN THEIR LIVES (P57)

34%
THE PROPORTION OF HIGHER LEVELS OF THE STRESS HORMONE NOREPHERPHINE EXPERIENCED BY DIVORCED COUPLES COMPARED TO COUPLES WHO ARE STILL MARRIED (P66)



MEDICAL ADVANCES




1910
WHEN KEYHOLE SURGERY WAS FIRST PERFORMED (P81)

AROUND 10 PER CENT OF ALL DIABETES IS TYPE 1, WHERE THE PANCREAS DOESN'T PRODUCE ANY INSULIN, AS OPPOSED TO TYPE 2, WHERE THE PANCREAS DOESN'T PRODUCE ENOUGH (P107)

TYPE 1 TYPE 2

DIABETES



2,500
THE NUMBER OF HEART TRANSPLANTS UNDERTAKEN IN THE US EVERY YEAR (P99)



100 BREAKTHROUGH HEALTH DISCOVERIES

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RALPH WALDO EMERSON

